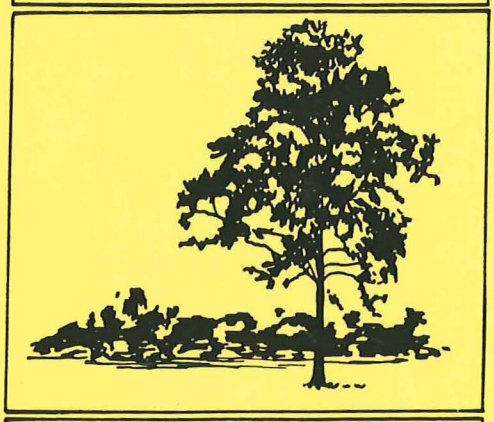


FOREST PEST CONDITIONS IN WISCONSIN

ANNUAL REPORT 1994

DEPARTMENT OF NATURAL RESOURCES
BOX 7921
MADISON, WISCONSIN 53707

FOREST PEST CONDITIONS IN WISCONSIN ANNUAL REPORT - 1994

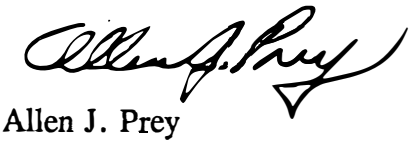
Compiled and Edited by Allen J. Prey,
David J. Hall, and Jane Cummings Carlson

DEPARTMENT OF NATURAL RESOURCES
Division of Resource Management
Bureau of Forestry

ACKNOWLEDGEMENTS

This record of the activities of forest pests and other destructive agents of growing trees in Wisconsin's forest nurseries, plantations, and natural timber areas was made possible by the dedicated work of pest management personnel in each district and at the Forest Pest Management Laboratory in Madison. Department of Natural Resources foresters, other Department field personnel, cooperators in other public agencies and private forest industry contributed valuable assistance in monitoring the forest lands in all classes of forest ownership.

Preparation of this Annual Report was a result of a team effort involving Andrea Diss, William Kearby, Todd Lanigan, and Shane Weber, DNR District Pest Specialists who submitted district reports. Jane Cummings Carlson and Dave Hall, Forest Pest Unit, Madison, consolidated the district reports and wrote the final draft. Final printing was done by the DNR Bureau of Program Services.



Allen J. Prey
Supervisor, Forest Pest Management

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DEPARTMENT OF NATURAL RESOURCES
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INTRODUCTION

This report lists the major insect, disease and other health problems reported on forest lean in Wisconsin in 1994. While the report does not list all the insect and disease problems that occurred on forest land, it does highlight major or noteworthy insect infestations and disease occurrences including abiotic damage to trees.

In 1994, insect and disease detection surveys were conducted on 6.4 million acres and evaluation surveys on 5.6 million acres. In addition, Wisconsin DNR district pest specialists continued to teach integrated pest management principles to Wisconsin DNR foresters, industrial foresters, and private woodland owners. District forest pest specialists and forest pest unit staff provided a wide variety of programs and information on forest pests in 1994.

OUTREACH

Presentations on IPM practices and updates on specific pest problems were given to the following groups and meetings: Wisconsin Woodland Owners Association; UW Stevens Point students; UW Madison students; Regional Stewardship Conference; Walnut Council; Wisconsin Arborists Association; Roche-A-Cri state park friends; Forest Productivity Council; Wisconsin Christmas Tree Producers Association; landowners in Jefferson, Beloit, Cottage Grove, and Fort Atkinson (gypsy moth public information); Bureau of Forestry staff; DNR & DATCP board meeting; Elementary schools; Forest Pest Advisory & Steering Council; DNR Area Managers; Wisconsin Electric Power Co.; officials and the general public in Winnebago, Brown, Oconto, Sheboygan, Marinette, Manitowoc and Peshtigo counties (gypsy moth); Kiwanis club; Loggers Conference; and 4-H camp.

Numerous radio interviews and press releases were conducted on topics including gypsy moth biology, trapping and management; oak wilt biology and management; ticks; jack pine budworm; black flies and mosquitoes.

Presentations were made at the following professional meetings: Biological Control Conference; American Phytopathological Society annual meeting; Audubon Society meeting; North Central Forest Pest Workshop; Wisconsin Arborists Association statewide meeting; and Sierra Club meeting.

The forest pest management exhibit showcasing the gypsy moth, oak wilt, walnut freeze injury and other pests was displayed at meetings of the following associations: Wisconsin Woodland Owners; Wisconsin Christmas tree growers; and various DNR district and area meetings and county fairs.

TRAINING

The forest health monitoring (FHM) crews (approximately 50 people) in the Lake State region were trained in FHM data collection. The forest inventory and analysis crews were trained in the new pest coding system for the lake states. Foresters, Christmas tree growers and woodland owners were trained on various topics including: identification and management of needlecast diseases; gypsy moth biology and silviculture; oak wilt biology and management; Karner blue butterfly; vegetation management; jack pine budworm; birch leaf miner; white pine blister rust; and walnut freeze injury.

Some or all of the forest pest specialists and forest pest staff attended numerous training sessions including: forest vegetation management; DNR computer training courses; hazardous materials; North Central Forest Pest Workshop; presentation skills; Natural Heritage Inventory; Wisconsin/ Michigan border pests; and train the trainer teleconference for EPA's Worker Protection Standards.

MEETINGS

Some or all of the forest pest specialists and forest pest staff attended the following meetings: USDA Forest Service state cooperators meeting; North Central Forest Pest Workshop; American Phytopathological Society annual meeting; Forest Health Monitoring planning sessions; Wisconsin Christmas Tree Growers Association meetings; and the National Gypsy Moth Meeting.

REPORTS, PAPERS AND VIDEOS

The following reports were completed: forest pest situation; accomplishment report and the annual report of forest pest conditions. A video entitled "Oak Wilt" which includes information on the biology and management of oak wilt was completed. Information sheets were written on herbicides for forestry; gypsy moth silviculture for oak; gypsy moth strategic plan and a manual code on biological control.

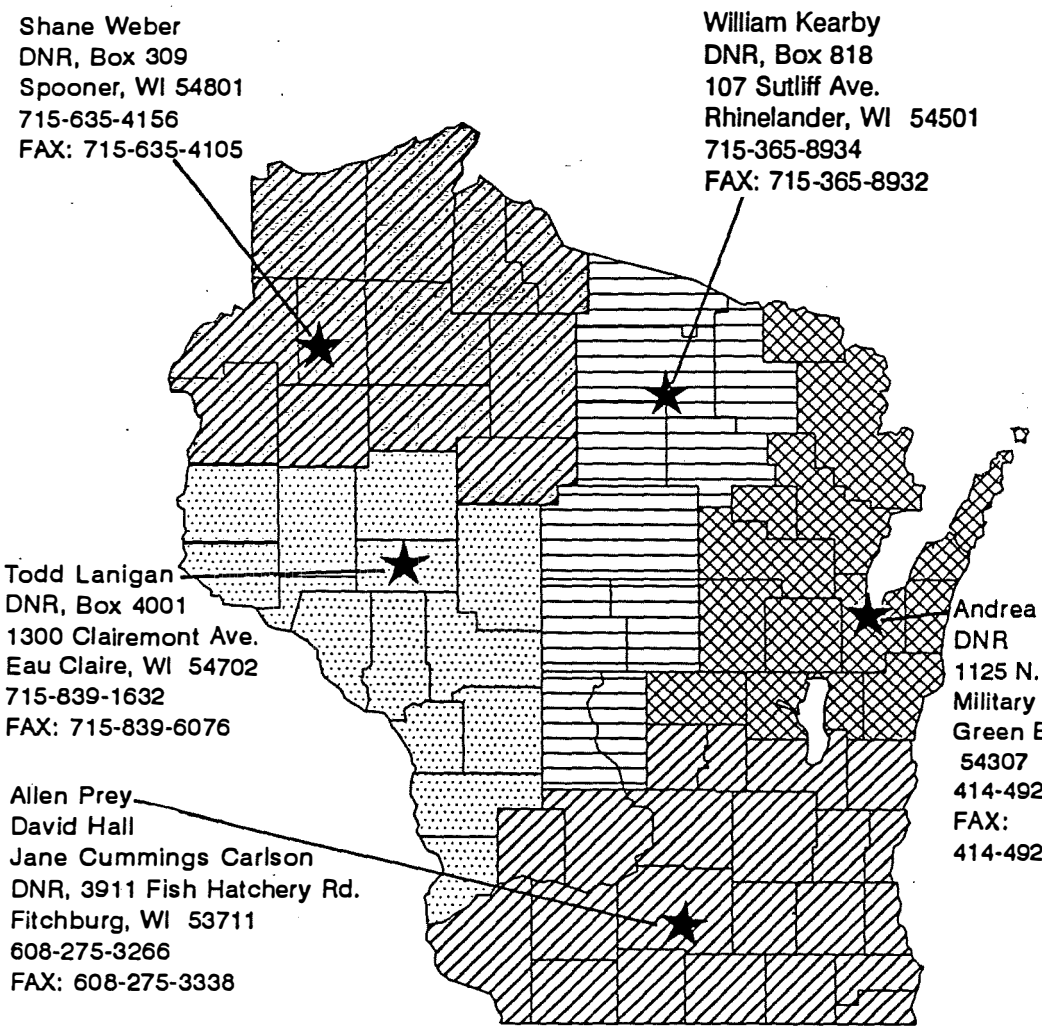

Figure 1. Station locations of Wisconsin Department of Natural Resources District Entomologists and Forest Pest Unit Personnel.

FOREST PEST CONDITIONS IN WISCONSIN
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ASH

Ash Yellows - Mycoplasma Like Organism (Phytoplasma)

A 1990-survey for ash yellows in Wisconsin's woodlands, revealed the presence of ash yellows in green and white ash in 4 townships (Figure 2). In 1994, urban foresters in Madison, Milwaukee and Waukesha participated in a survey for ash yellows in urban ash trees. Up to 40 ash trees, >6 inches in diameter, were sampled in each community. Samples were collected from the trees' root systems and sent to Iowa State University for analysis. The DAPI stain technique was used for confirmation of the presence of the phytoplasma. Sampled trees were also evaluated for dieback, foliage transparency and density. The presence of witches' brooms, epicormic sprouts and basal bark cracks was also noted. Increment cores were taken from the sampled trees to determine whether or not a decrease in radial growth was occurring on sampled trees. Preliminary results showed 1 tree in Madison, 4 in Waukesha and 6 in Milwaukee were positive for the presence of ash yellows. This survey will continue in 1995. Emphasis will be on intensifying the survey in areas of the communities where ash yellows has been confirmed. A full report from Iowa State University is expected in 1996.

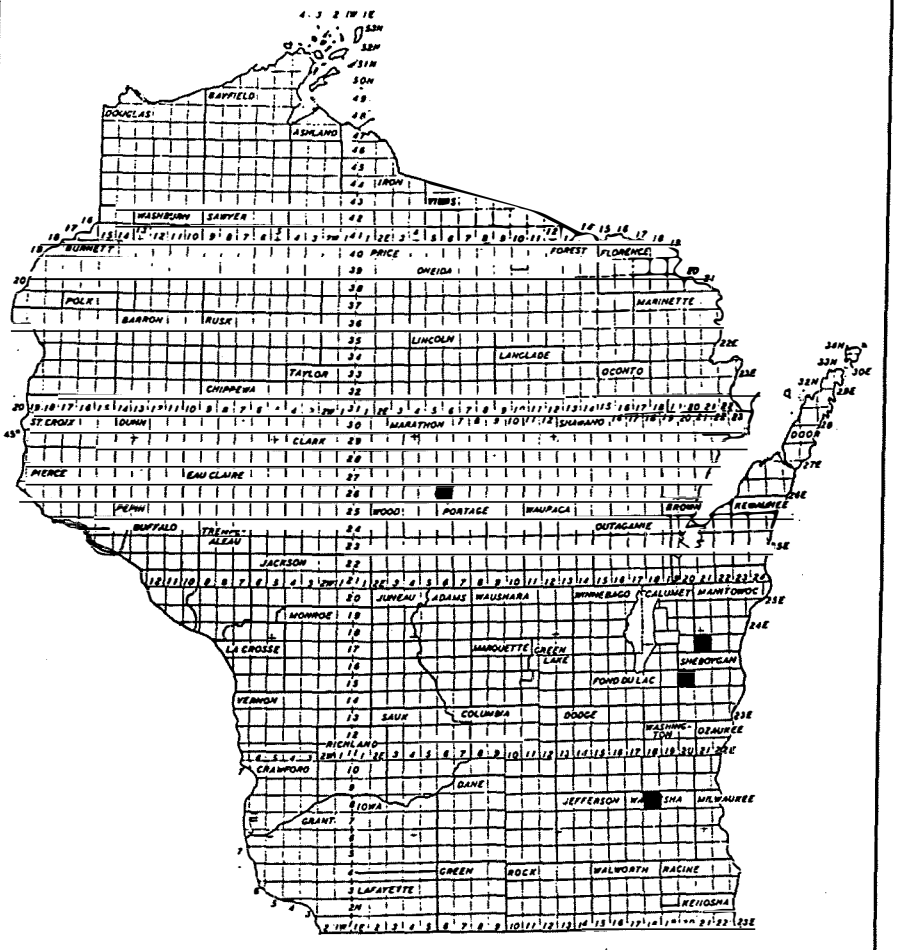


Figure 2. Known Township Locations of Ash Yellows in Wisconsin woodlands, 1994.

Ash Flowergall Mite - *Eriophyes fraxiniflora* Felt

This pest was a minor problem on urban ash species in the cities of Green Bay and Manitowoc, eastern Wisconsin.

Ash Plant Bug - *Tropidosteptes amoenus*

This insect was observed in Marathon County where leaves were browned and distorted on green ash on urban sites.

Black-headed Ash Sawfly - *Thethida barda* (Say)

Colonies of black-headed sawfly larvae were observed feeding on green ash leaves in urban sites in Marathon County.

ASPEN

Forest Tent Caterpillar - *Malacosoma disstria* (Hubner)

Populations of this hardwood defoliator collapsed after several years of outbreak levels. No defoliation was observed.

The winter egg mass survey of seven sites across Marinette County yielded nine egg masses from three sites, a dramatic decrease from the large numbers found up to two years ago. The small size of most of the masses collected indicated the poor condition of the maternal parent. Temperatures below -30 °F did not kill pharate larvae. No defoliation could be attributed to this pest in 1994.

Aspen blotch miner - *Phyllonorycter tremuloidiella* (Braun)

This pest caused discoloration and defoliation of aspen in several northeastern counties and was especially noticeable in Lincoln, Shawano and Marinette counties.

BALSAM FIR

Spruce Budworm - *Choristoneura fumiferana* (Clemens)

Populations were very low over most of northern Wisconsin except in Oneida County where light to moderate defoliation of balsam fir occurred, T38N, R11E, Section 31 and T39N, R10E, Section 31. Industrial foresters reported many moths flying in Section 31, T38N, R11E on June 23.

Balsam Gall Midge - *Paradiplosis tumifex* (Gagne)

Light infestations occurred in natural balsam fir stands on open, upland sights in Oneida, Lincoln and Langlade counties.

BIRCH

White Birch Dieback and Mortality - Drought

White birch is recovering in north-central Wisconsin after years of severe stress. The evaluation of monitoring plots in Oneida County revealed no change or accelerated increase in tree mortality in 1994.

Birch Leafminer - *Fenusa pusilla* (Lepeletier)

Populations were very low in the forests of northern Wisconsin. The usual moderate to heavy leaf mining of ornamental trees occurred in many areas of northern Wisconsin.

BLACK WALNUT

Walnut Freeze Injury

Reports of dead and dying black walnut from freeze injury were wide spread in 1994 from LaCrosse, Trempealeau, Vernon, Richland, Crawford, Grant and Iowa counties in southwest Wisconsin and southeast Minnesota (Figure 3). Affected walnuts were in valley-bottoms or in areas where a valley narrows and forms steep slopes on either side of the trees. All sites examined appeared to be well-drained and are considered some of the better walnut sites. Streams were common in these valleys although not present on all sites.

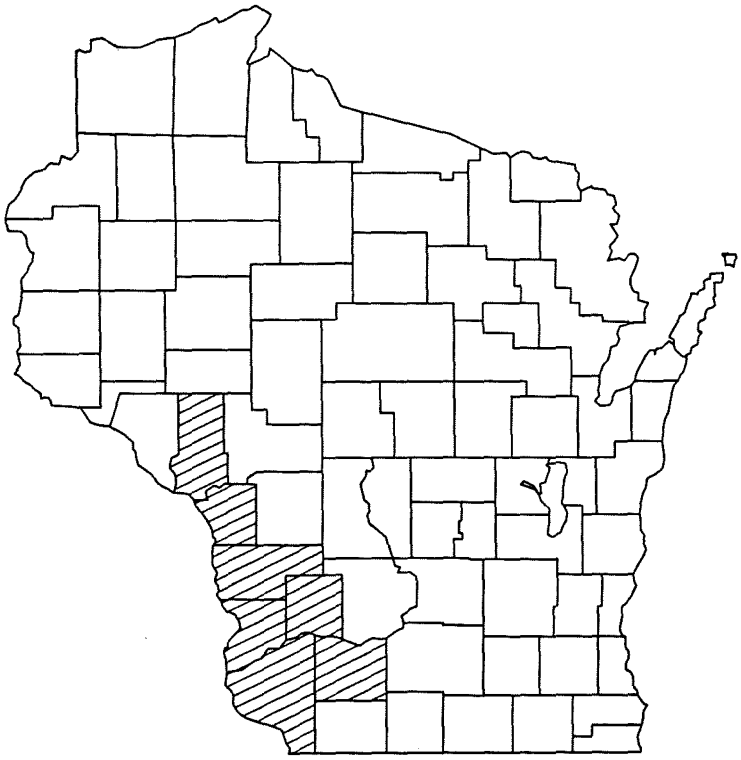


Figure 3. Counties where freeze injury occurred on Black Walnut during the winter of 1993-94.

Injured trees ranged from 4 inches to 14 inches in diameter. Walnuts in natural stands, pure plantations and in plantations mixed with white pine were affected. Trees injured fell into the following categories: 1) upper branch dieback, 2) crown dead, sprouts present on the main stem, 3) crown dead, sprouts present at the base, and 4) whole tree dead, no sprouts. When bark was removed from the freeze-injured trees, the cambium was black and often had wood borers (in the larval stage) feeding in the dead regions. The fungus Fusarium was found fruiting on the bark of dead branches and the main stem. The wood borers and Fusarium fungus are secondary organisms but will contribute to an injured walnut's demise. The most severe losses were observed in LaCrosse County were up to 80 percent of the walnut were injured in areas on the Coulee Experimental Forest. Less severe losses occurred in some natural stands in Richland County.

The most important factor influencing injury appears to be landscape position. Dead and dying trees were observed in areas where cold air settles (valley-bottoms) while unaffected walnuts were observed up the sides of the valley or on the ridge tops. Other species that suffered from this freeze injury in these same areas include multi flora rose and autumn olive.

Similar injury to black walnut, through not as widespread, occurred in 1988. Comparisons of the weather records show that very low temperatures occurred in January of 1988 and 1994 in several locations in southwest Wisconsin (Figures 4 and 5). Other factors such as mild temperatures preceding the cold periods or widely fluctuating temperatures do not appear to have been the primary cause of injury. Black walnut in southwest Wisconsin and southeast Minnesota is in its most northern range. Thus walnuts in valley-bottoms at the northern extent of the tree's range are most susceptible to freeze injury.

The following recommendations have been made regarding injured trees:

1. Severely injured trees with more than 50 percent of the crown dead. These trees will continue to have problems with decay fungi and infection by Fusarium. Fusarium has caused fatal cankers on black walnut in Wisconsin and Minnesota and will probably invade the dying tissues. These trees can be cut to encourage basal sprouts. Smaller, younger trees will usually produce sprouts; larger, older trees may not. Cutting should be done during the dormant season (September through April) to limit the impact of Fusarium canker. Trees that produced no foliage in 1994 are not likely to produce basal sprouts. A year or two after cutting, the sprouts should be thinned; the most vigorous sprout originating near the root collar should be left. Discriminate against slow-growing sprouts and sprouts originating high on the stump.

2. Moderately injured trees with less than 50 percent of the crown dead. Some of these trees will survive. The dead branches will deteriorate and serve as an entry point for decay. Some of the healthier trees on the better sites will wall off the decay and limit its impact. These trees can either be left or cut to encourage the production of sprouts. Some of the trees will eventually be overcome by decay fungi, Fusarium, and wood borers and deteriorate. Diversify! Restrict future plantings to areas where walnuts survived this freeze injury. Avoid planting pure stands of walnut in valley-bottoms or in areas where a valley narrows and has steep side slopes.

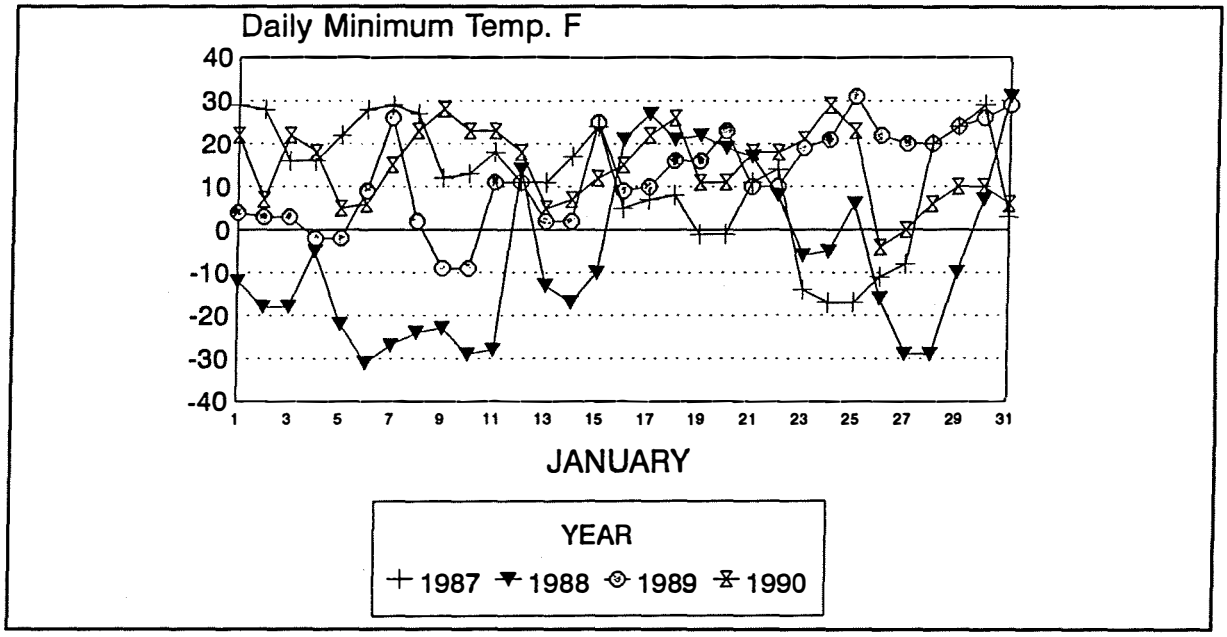


Figure 4. Daily minimum temperature degrees F in Gays Mills, WI during January of 1987, '88, '89 and '90.

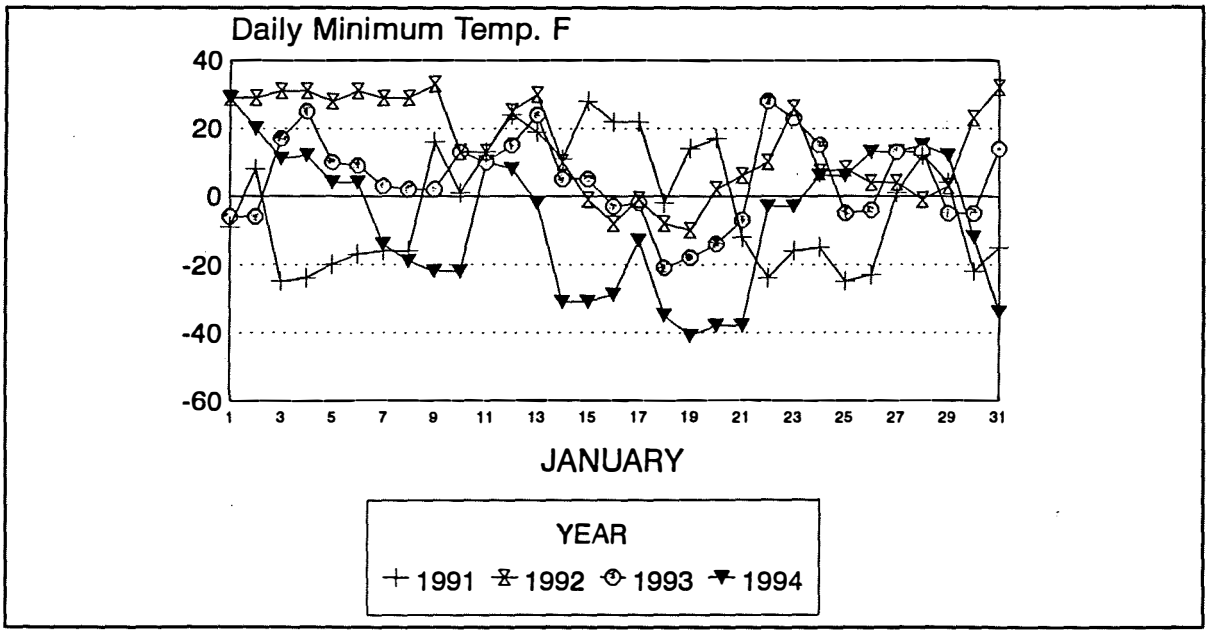


Figure 5. Daily minimum temperature degrees F in Gays Mills, WI during January of 1991, '92, '93 and '94.

BUTTERNUT

Butternut Canker - *Sirococcus clavigignenti - juglandacearum* (Nair, Kostichka and Kuntz)

The known county distribution of butternut canker did not change in 1994 (Figure 6). Activities regarding butternut focused on public information, seed collection, and silviculture. The Bureaus of Endangered Resources and Forestry within DNR are working together to inform the public on the health status of butternut and solicit help in nut collection and planting of butternut nuts and seedlings. Presentations were given to organizations such as the Wisconsin Woodland Owners' Association (WWOA) and an article on these same topics appeared in the first WWOA journal for 1995. Approximately 25 bushels of nuts were collected by the public for planting at the DNR Hayward state forest tree nursery. Emphasis will continue on providing the public information on successful planting and growing of butternut.

A cooperative project with the Menominee Tribal Enterprises, initiated in 1993, continued in 1994. The objectives of the project are to: 1) evaluate the survival and growth of planted butternut in various sized canopy openings on 2 habitat types; 2) test the hypothesis that butternut can survive to a seed-bearing age (even if infected with butternut canker) if planted on habitat types best suited for growing butternut; and 3) increase our understanding of the silviculture of butternut and refine the silviculture guidelines for butternut based on the study results. Approximately 1,200 2-0 butternut seedlings will be planted on 5 different sized openings (.03 acre, ¼ acre, ½ acre, 1 acre and 2 acres) in the spring of 1995. Each plot size is replicated 3 times. Plots are located on 2 habitat types; AQVib (Acer-Quercus/Viburnum) and ATF (Acer-Tsuga-Fagus/ Dryopteris).

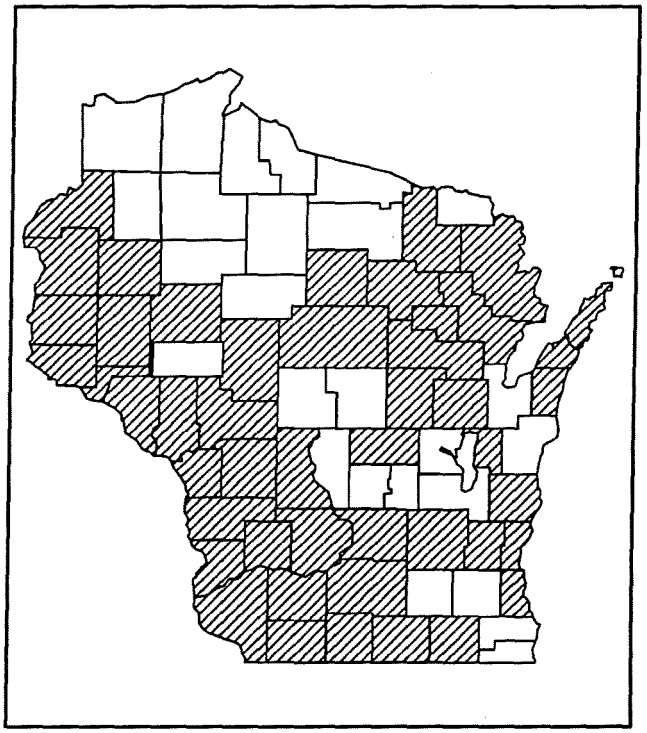


Figure 6. Known county locations of Butternut Canker, 1994.

Table 1. Other reported pests of Christmas trees.

PEST	DESCRIPTION	LOCATION
Yellow-Headed Spruce Sawfly - *Pikonema alaskensis* (Rohwer)	Spotty heavy defoliation in a 3-4 acre white spruce plantation	Lincoln County
Pine Spittlebug - *Aphrophora parallela* (Say)	Heavy branch mortality in a 9 year old Scotch pine plantation. Damage prevented sale of trees.	Langlade County
Root Rot of Balsam Fir Seedlings - Pythium sp.	Heavy mortality of 2 to 4-year-old seedlings in a private nursery .	Price County
Spruce needle discoloration - Unknown	Chlorosis, necrosis and desiccation of white spruce needles on 4-6' tall Christmas trees.	St. Croix County
Cytospora Canker - *Leucostoma kunzei*	Cytospora canker was identified on blue spruce Christmas trees.	Oconto County
White Pine Blister Rust - *Cronartium ribicola*	Light to moderate infestations in white pine Christmas trees.	St. Croix and Vernon counties
Eastern Gall Rust - *Cronartium quercuum*	Light infestation in Scotch pine Christmas trees.	St. Croix and Waushara counties
Spruce gall midge - *Mayetiola picea*	A heavy infestation was observed on branches of individual trees in spruce Christmas trees.	Shawano County
White Pine Aphid - *Cinara strobi* (Fitch)	Thirty white pines were heavily infested. Sooty mold was heavy and many overwintering eggs were present late in the growing season.	Dunn County
Balsam Twig Aphid - *Mindarus abietinus* (Koch)	Light infestations caused some needle distortion in lower crowns in balsam fir Christmas trees.	Langlade, Price, Portage and Winnebago counties
Balsam Fir Broom Rust - *Melampsorella caryophyllacearum*	Heavy infestation in wild balsam stand grown for Christmas trees on 80 acres, every tree evaluated showed developing brooms.	Langlade County
Balsam Fir Broom Rust - *Melampsorella caryophyllacearum*	Observed on scattered balsam fir Christmas trees.	Waushara County
Meadow vole - *Microtus pennsylvanicus*	Extensive damage caused by feeding.	Oconto and Marinette counties

LARCH

Larch Top Dieback and Mortality - Unknown

Japanese larch at 2 sites in Waushara County died as a result of unknown causes. These trees grew vigorously in previous years. Sawflys and bark beetles attacked them this year; however, the damage from these pests was not sufficient to account for the mortality observed.

A plantation of Japanese/European hybrid larch on the Coulee Experimental Forest (planted in 1984) in LaCrosse County, western Wisconsin, was surveyed to determine the impact and possible progression of top dieback and mortality that was first observed in 1992. Symptoms in 1992 included top dieback, mortality, needle chlorosis, and pitchy cankers or splits in the bark. The injuries were attributed to late spring frosts in 1992. These stands were surveyed in 1993 and 1994. No dramatic increase in the number of dead trees or trees with dead tops occurred in 1994. These stands will be resurveyed in 1995.

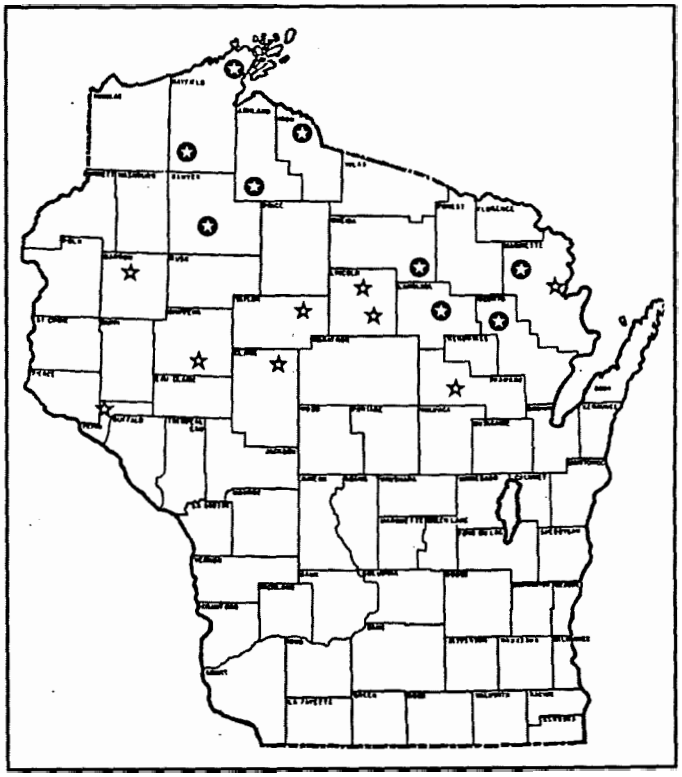
Larch Sawfly - *Pristiphora erichsonii* (Hartig)

Sawflys caused light, spotty defoliation in a pole-sized Japanese larch plantation in Waushara county.

MAPLE

Sugar Maple Decline Survey - North American Maple Project

Figure 7. Location of North American Maple Project plots
Sugarbush = star
Sugar Maples not tapped = star inside circle



Wisconsin continued to participate in the North American Maple Project, administered by the USDA Forest Service and Canadian Forestry Service. Eighteen plots, (Figure 7) (each plot a cluster of 5, 20 x 20 meter plots), were established in 1988; 9 plots have trees tapped for maple syrup, and 9 plots have trees that were not tapped for maple syrup. Each year, data on tree vigor, dieback, discoloration, dwarfing and crown transparency have been collected. In 1995, a report was published entitled Temporal Change in Sugar Maple Crown Condition From 1988 - 1994 (Andrew W. Molloy and Douglas C. Allen, State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 13201, March, 1995). Table 2 and the following summary were taken from this report.

Table 2. Average cluster dieback ratings for live, dominant/codominant sugar maples by year (1988 - 1994) and management category, in Wisconsin.

	AVERAGE CLUSTER DIEBACK (%)								
	Sugarbushes			*Nonsugarbushes*			*All*		
Year	%	± 1 SE	n	%	± 1 SE	n	%	± 1 SE	n
1988	8.6	± 0.9	9	9.0	± 0.8	9	8.8	± 0.6	18
1989	7.8	± 0.7	9	6.6	± 0.6	9	7.2	± 0.5	18
1990	9.8	± 1.1	9	9.6	± 0.6	9	9.7	± 0.6	18
1991	8.3	± 0.8	9	7.4	± 0.9	9	7.8	± 0.6	18
1992	2.4	± 0.7	9	0.8	± 0.4	9	1.6	± 0.4	18
1993	4.9	± 0.4	9	5.0	± 0.4	9	5.0	± 0.3	18
1994	5.9	± 0.4	9	5.8	± 0.4	9	5.9	± 0.3	18

* Analysis of variance and a multiple comparison procedure were used to compare plot-cluster averages. Results are included only for the subpopulation of dominanat/codominant sugar maples greater than 10cm d.b.h.

Average cluster dieback in Wisconsin has increased since 1992, yet ratings have not approached pre-1992 levels. Dieback ratings in 1993 and 1994 were lower than project-wide ratings. Prior to 1992, however, Wisconsin ratings were higher than project-wide ratings. There were statistically significant decreases in dieback within all three management categories (sugarbush, nonsugarbush, combined) from 1991 to 1992 (5.9 to 6.6 percent). Dieback increased from 1992 and 1993 in the nonsugarbush and combined management categories by 3.4 to 4.2 percent. The 1988 vs. 1994 comparison revealed a statistically significant decrease in average cluster dieback in the nonsugarbush and combined management categories (2.9 to 3.2 percent). None of 7 annual comparisons between dieback averages in sugarbushes and nonsugarbushes were statistically significant. Three plot-cluster pair/triplets had statistically significant dieback averages in 1993 and 1994 (all less than 4 percent). Graphically, from 1992 to 1994, dieback distribution ratings shifted out of the 0 percent rating class and into the 5 percent class (a 70 percent increase in the latter). A severe drought that occurred in Wisconsin in 1988, affecting all Wisconsin NAMP plot-clusters, was not reflected in changes in crown dieback.

Molloy and Allen noted that 2 years following the severe drought in 1988, the principal effect on sugar maple crowns appeared to be increased transparency. They also stated that by 1992, the transparency ratings returned to 1988 levels indicating that the length of time required for sugar maple crowns to return to predrought conditions was 4 years.

The average annual natural mortality of sugar maples for the period 1989 to1994 was 0.5 percent. Average annual management-related mortality was 0.6 percent. Cumulative annual natural mortality as of 1994 was 3.1 percent (33 of 1,061 trees). Average annual natural mortality was higher for sugarbushes than nonsugarbushes with all crown positions combined (0.7 percent vs. 0.4 percent) and higher for trees in intermediate/suppressed crown positions than for dominant/codominant trees (0.9 percent vs. 0.3 percent). When compared to the project as a whole, average annual natural mortality in Wisconsin was lower (0.5 percent vs. 0.9 percent). Average annual total mortality, which includes both natural and management-related mortality, was also lower in Wisconsin than for the project as a whole (1.1 percent vs. 1.2 percent).

Sugar Maple Anthracnose - *Discula campestris* (Pass.) Von Arx

Dr. Glen Stanosz, UW-Madison plant pathologist, identified this pathogen in understory sugar maple in mixed hardwood forests of Oneida County in June, 1993 and on large, open-grown, ornamental sugar maple in Oconto County, August, 1993. Dr. Stanosz observed irregular, brown to black necrotic areas along and between leaf viens and on the leaf margins. Damage was considered light. This is the first report of this disease in Wisconsin.

Sugar Maple Decline - Fluctuating water table

Fluctuating water tables and damage during an earlier harvest stressed trees leading to decline and mortality at 2 sites in Winnebago and Calumet counties.

Red Maple Dieback and Mortality - Fluctuating water table

Early leaf coloration the third week of July and tree mortality occurred in Adams, Juneau and Wood counties are due to previous flooding and cool wet soils.

Maple Trumpet Skeletonizer - *Epinotia aceriella* (Clemens)

This late-summer defoliator damaged Norway and sugar maple throughout Door County.

Cottony Maple Scale - *Pulvinaria innumerabilis*

Very light infestations of scale occurred in Eau Claire County.

MISCELLANEOUS

Unidentified Tussock Moth

Small dried larval skins and egg masses were found on Colorado blue spruce in Lincoln County that may be *Dasychira spp.*

Anthracnose - A variety of fungi

Scattered reports were noted throughout the Western District; this pest was most common on ash, maple, and oaks. Red oak in Marathon County was moderately infected.

Rhizosphaera Needlecast - *Rhizosphaera kalkhoffii*

Light to moderate damage on windbreak and yard Colorado blue spruce was observed throughout the Western District.

Winter Freeze

Extreme cold winter temperatures in January killed or caused severe dieback on ash, cherry, maple, and plum trees in Buffalo, Chippewa, Pepin, and Pierce counties. Norway maple and catalpa suffered extensive mortality and crown dieback in the northwestern counties.

Frost

Late frosts caused damage to lower crowns of oaks in Marinette and Florence counties. Moderate damage occurred on foliage of red oak and bur oak in Jackson and Monroe counties. Heavy mortality occurred to young leaves on oaks in Vilas, Forest, Oneida, Juneau, Wood and Adams counties.

New growth was killed on Balsam fir in scattered low lying plantations in Langlade, Oneida, Lincoln, Price and Taylor counties.

Mechanical Injury

Road clearing crews using rotary pruners savaged trees along roads in Marinette County. Many trees were notched or deeply gashed. This clearing method, as used, leaves trees structurally weakened and susceptible to attack by insects and pathogens. Injuring trees does not seem consistent with the goal of increased safety.

Tornado Damage

On Memorial Day, May 30, a tornado touched down southwest of Crandon in Forest County and cut a 12-mile swath eastward to just southeast of the Laona cemetery (Figure 8). An immediate salvage effort began on Forest County, Bureau of Indian Affairs, and Wisconsin Timber Associates (WISCO) limited Partnership lands. Approximately 954 acres were affected.

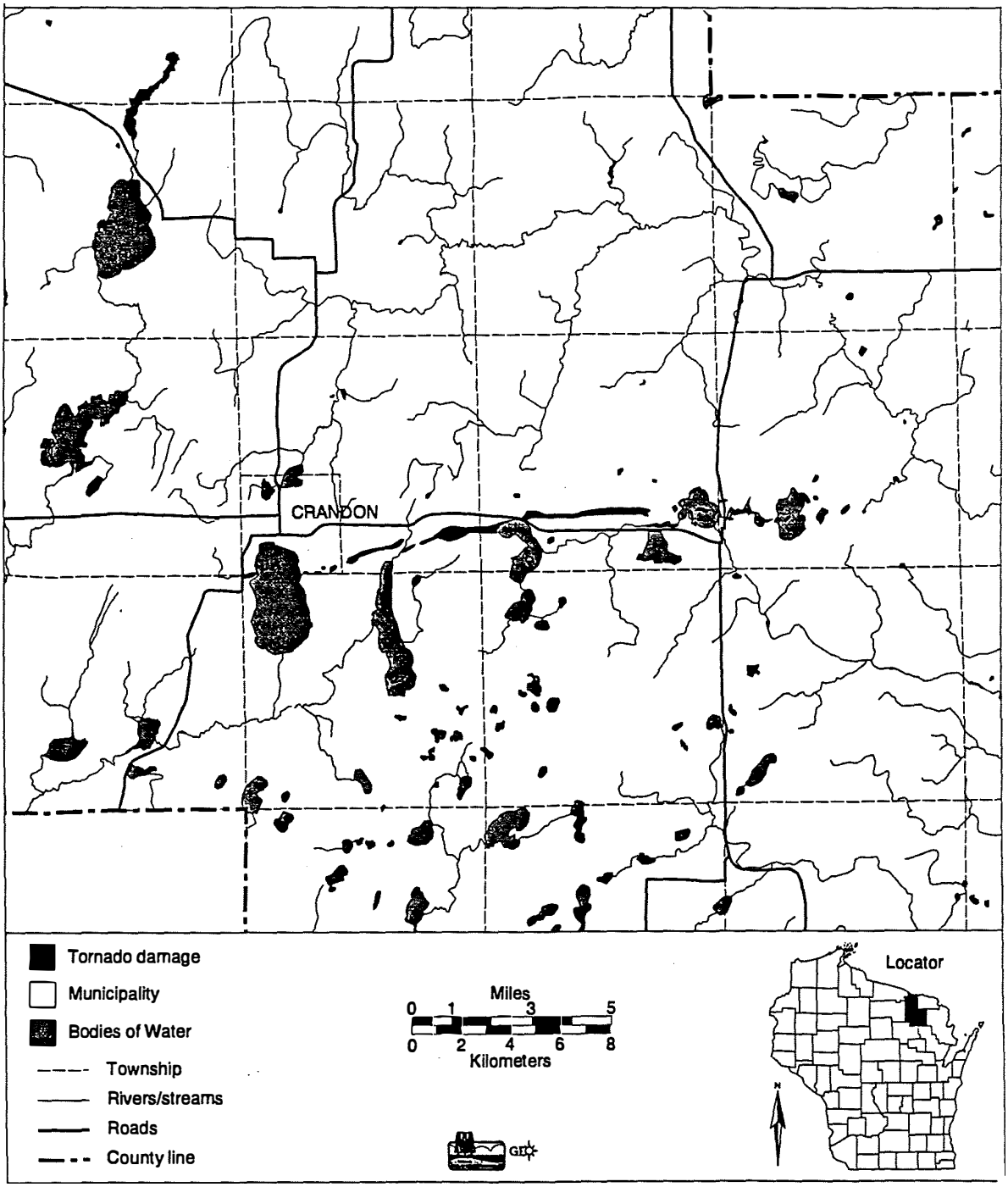


Figure 8. Touch-down area of May 30 tornado in Forest County.

Table 3. Timber salvage statistics, Forest County Forest tornado damage, 1994.

SALE #	VOLUME (CORDS)	VOLUME (M BOARD FT.)	APPRAISED VALUE	SOLD VALUE	ACRES
1	240	30	$ 2,922.00	$14,155.00	28
2	520	41	$ 4,662.00	$22,615.00	36
3	500	10	$ 3,088.00	$ 9,711.50	44
4	400	5	$ 2,036.00	$ 5,600.00	25
5	440	10	$ 2,596.00	$ 7,480.00	33
TOTAL	**2,100**	**96**	**$15,304.00**	**$59,561.50**	**166**

Table 4. Timber salvage statistics Potawatomi Indian Reservation and WISCO lands, tornado damage, 1994.

Table 4: Timber Salvage Statistics Potawatomi Indian Reservation *(from BIA Forester Hans Schmitt)*	
Total Acres	188
Total Estimated Salvage:	
Saw Timber	139 MBF
Cords	2,431
Value	$52.783.00
Salvaged to Date:	
Saw Timber	76.94 MBF
Cords	1,715
Value	$27,330.00

Table 5: Timber Salvage Statistics Wisconsin Timber Associates *(from Nicolet Hardwoods Forester Ken Mullins)*	
Total Acres	600
Total Estimated Salvage:	
Saw Timber	1,600 MBF
Cords	2,000

On August 24, 1994, a tornado struck the Big Flats area, Adams County, (Figure 9) and destroyed the fire station, small businesses, and numerous homes. Jack pine, red pine, white pine, and scrub oaks were the species damaged on 1,380 acres, most in private small ownership.

Table 6: Timber Salvage Statistics from the August 24, 1994 tornado, Adams County.

Volume	300 Cords	Sold Value	$6,000

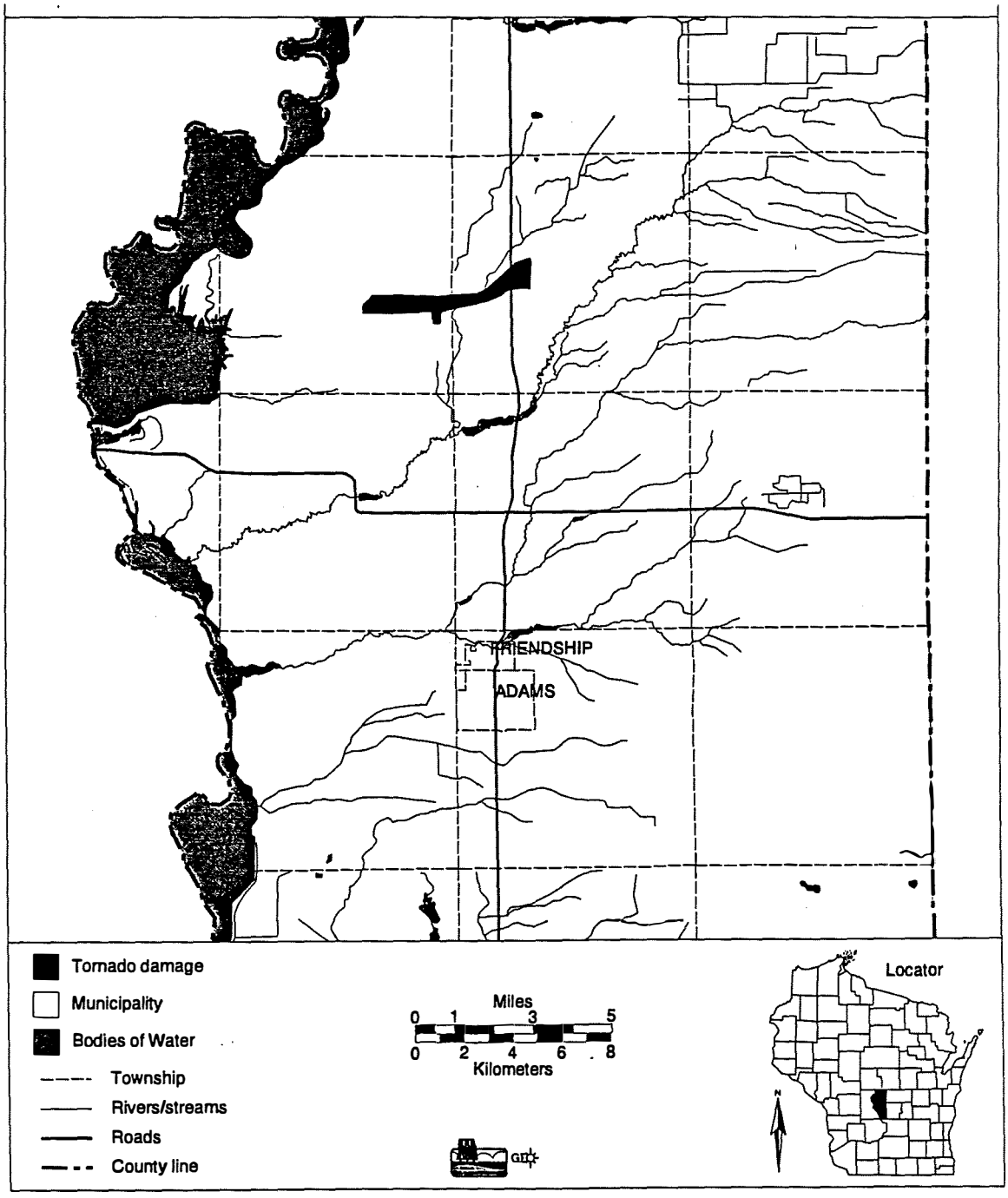


Figure 9. Area where tornado of August 24 damaged property and timber, Adams County.

Road Salt Injury

Red and white pines were affected throughout the Western District along major highways and roads. Also, road salt caused browning of needles on red pine along major highways in the Lake Michigan District.

Chainspotted Geometer - *Cingilia catenaria* (Drury)

A small population was found again this year feeding on Labrador Tea in Chippewa County.

Pear Sawfly - *Caliroa cerasi* (L.)

There was heavy skeletonizing of cherry and mountain ash foliage in Dunn, Eau Claire, and St. Croix counties.

Gypsy Moth - *Lymantria dispar* (L.)

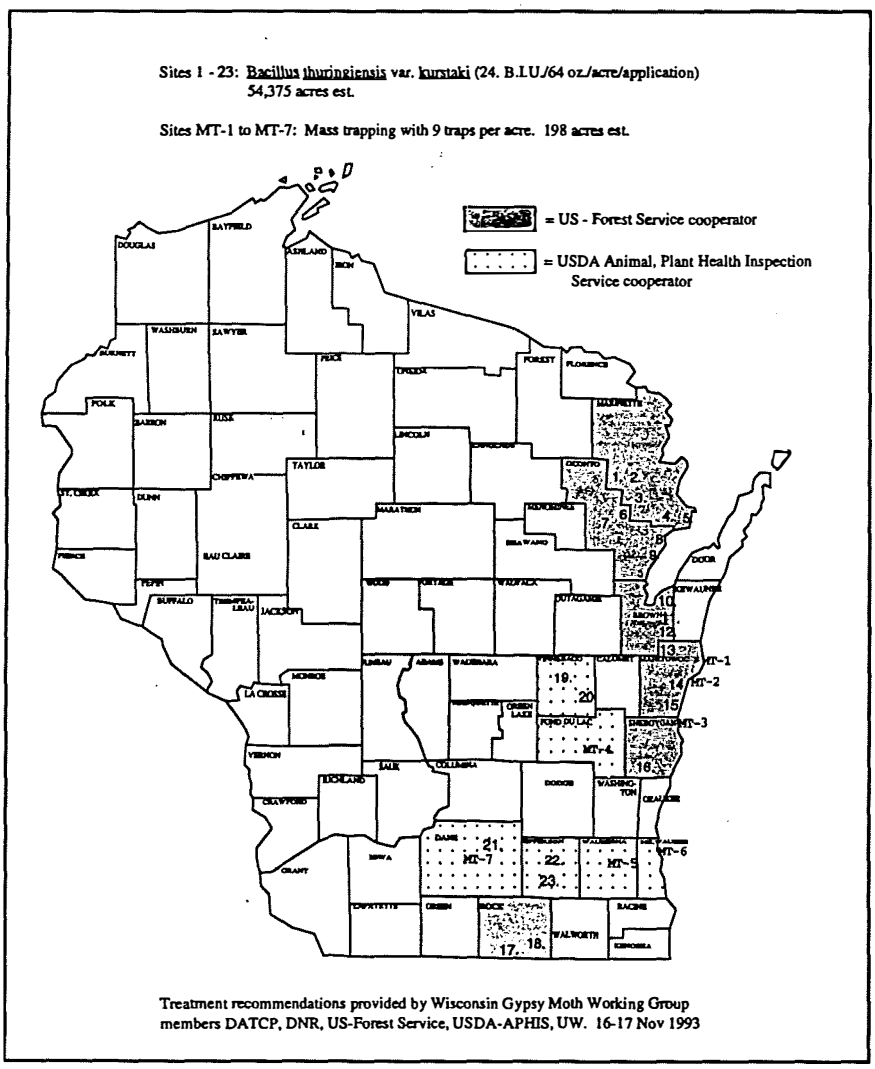

Sites 1 - 23: Bacillus thuringiensis var. kurstaki (24. B.I.U./64 oz./acre/application)
54,375 acres est.
Sites MT-1 to MT-7: Mass trapping with 9 traps per acre. 198 acres est.
= US - Forest Service cooperator
= USDA Animal, Plant Health Inspection Service cooperator
MT-1
MT-2
MT-3
MT-4
MT-5
MT-6
MT-7
Treatment recommendations provided by Wisconsin Gypsy Moth Working Group members DATCP, DNR, US-Forest Service, USDA-APHIS, UW. 16-17 Nov 1993

Figure 10. Gypsy Moth control sites, 1994.

Twenty-three sites in 9 counties, totaling 51,003 acres were sprayed 2 or 3 times with 1 gallon per acre of *Bacillus thuringiensis* (B.t.) (Figure 10). Eleven sites totaling 418 acres were treated with mass trapping with 9 delta traps per acre. Over 27,200 additional traps were placed for detection, delimitation and to monitor the effectiveness of the B.t. applications. Egg mass surveys were conducted in areas that produced high trap catches.

The trap catch was reduced greatly from the 1993 level. A total of 9,599 male moths were trapped in 39 counties (Table 7). The severely cold winter temperatures are known to have killed many eggs. The trap catches in the sprayed areas were very low, and only a few new egg masses were found.

The greatest concern is the scattering of trap catches in the central and western counties. Infested logs are known to have been imported into Marathon and Ashland counties. Infested nursery stock has been imported in past years and may be responsible for some of these trap catches.

Three years of mass trapping has proven that it can be applied successfully. The high density of traps (9 per acre) pinpoints population centers and allow intensive, focused egg mass surveys. The removal of the egg masses is an important part of the population reduction caused by this approach. A report on 3 years of mass trapping in Wisconsin is in preparation.

The current plan for 1995 calls for spraying about 30,000 acres in 20 sites with 2 applications of B.t. and mass trapping 4 sites totaling 1,090 acres.

The Incident Command System (ICS) was again used to organize the activities of two state and 2 federal agencies to conduct all the gypsy moth treatment and surveillance activities in 1994. Wisconsin Department of Natural Resources; Wisconsin Department of Agriculture, Trade & Consumer Protection; the U.S. Forest Service; and the U.S.D.A. Animal & Plant Health Inspection Service cooperated under a "Unified Command" structure.

After a 20-month effort, the above-mentioned agencies succeeded in finalizing The Wisconsin Gypsy Moth Strategic Plan. The U. S. D. A. Forest Service, Forest Health Protection, provided funding to hire a consulting firm, The Institute for Environmental Negotiation, to facilitate the discussion and drafting of the plan.

Table 7: Male gypsy moth trap catches as of September 29, 1994.

COUNTY	MALE MOTHS CAUGHT	COUNTY	MALE MOTHS CAUGHT
Ashland	20	Milwaukee	372
Barron	1	Monroe	1
Bayfield	2	Oconto	60
Brown	39	Outagamie	9
Calumet	3	Ozaukee	52
Chippewa	3	Polk	3
Clark	2	Portage	5
Dane	36	Racine	73
Door	8,067	Rock	45
Eau Claire	28	St. Croix	2
Fond du Lac	7	Sheboygan	121
Forest	2	Taylor	1
Green Lake	3	Trempealeau	1
Jefferson	2	Vilas	2
Kenosha	137	Walworth	73
Kewaunee	59	Washington	18
La Crosse	3	Waukesha	65
Manitowoc	169	Winnebago	12
Marathon	33	Wood	11
Marinette	57		
		Total	**9,599**

Hickory Bark Beetle - *Scolytus quadrispinosus*

Several areas of shagbark hickory mortality were reported in Columbia County. One area of heavy mortality was salvaged by a clearcut harvest.

Mountain-ash Sawfly - *Pristiphora geniculata* (Hartig)

Unusually high populations caused heavy defoliation on ornamental mountain-ash in many northern counties.

Wood Tick - *Dermacenter variabilis* spp.

There were high numbers of ticks attached to clothing during May and June in Adams, Juneau and Wood counties. Populations declined from the high 1993 levels in the northeastern counties.

Flooding

Flooding and bark beetle and wood borer infestations caused mortality in a red pine plantation in Shawano County.

NURSERY

White Pine Seedling Root Rot - *Fusarium* spp.

The USDA Forest Service continued to study the factors affecting this disease of white pine seedlings. Two reports were submitted by cooperators, Jennifer Juzwick and Cynthia Ocamb, USDA Forest Service Research Plant Pathologists, North Central Forest Experiment Station (NCFES). See Appendix A for progress reports.

OAK

Oak Wilt - *Ceratocystis fagacearum* (Bretz) Hunt

Oak wilt was not observed in any previously unreported counties (Figure 11). Surveys continue to be concentrated in counties along the northern extent of this disease. New infections were confirmed in Mosinee and Kronenwetter in Marathon County. Large pockets of oak wilt were observed in northern pin oak in Adams, Juneau, Wood and Portage counties. In Marinette County, oak wilt has been observed west of the city of Wausaukee, in Athelstane. This is the farthest west in the county oak wilt has been observed. Construction of houses on forested land appears to be associated with the spread of oak wilt west of Niagara in northern Marinette County. The Niagara tree board started organizing a control program to slow the spread of wilt within the city limits. An increase in interest by the general public occurred primarily as a result of the information and education campaign waged by the Wisconsin Garden Club Federation. A video, "Oak wilt, its biology and management," was produced in cooperation with the Illinois Natural History Survey and is now available.

* Guidelines for Pruning Oak to Minimize the Overland Spread of Oak Wilt - See Appendix B.

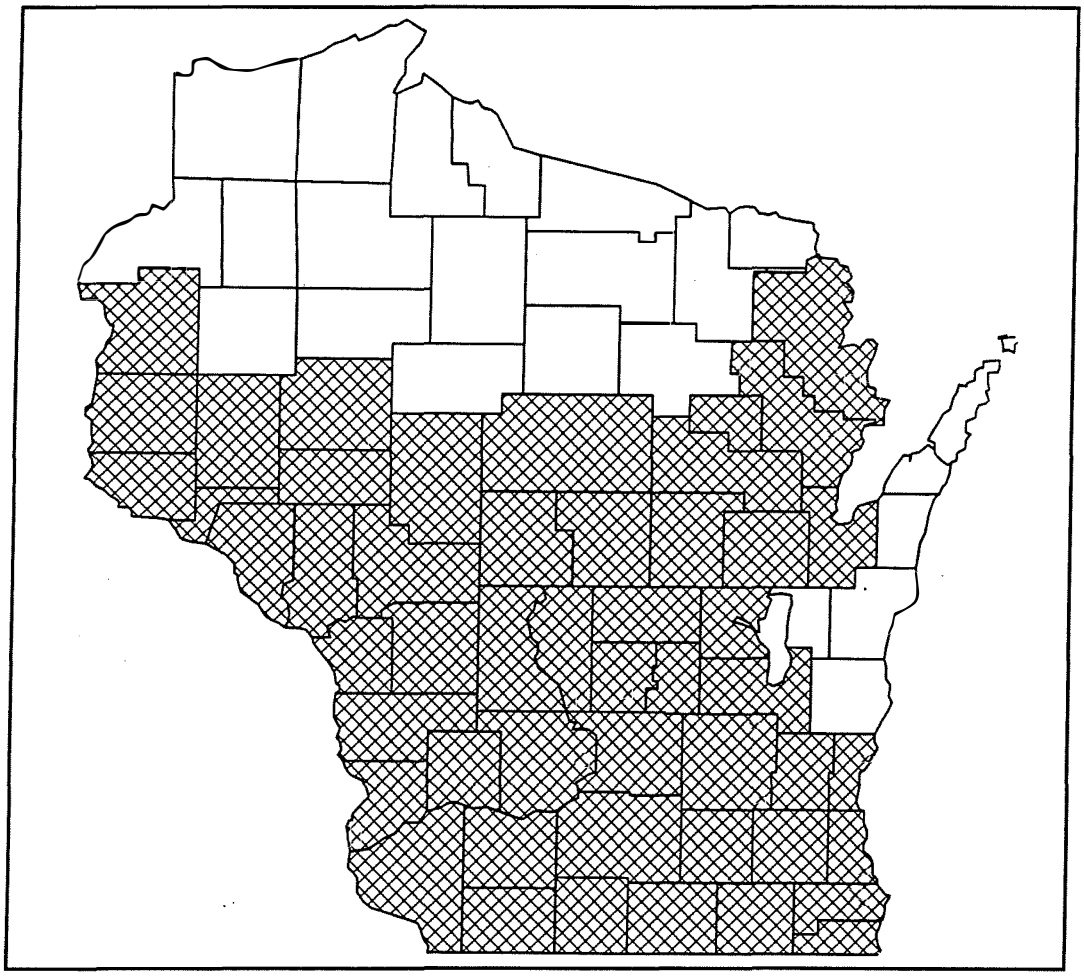


Figure 11. Known county distribution of oak wilt, 1994.

Two-lined Chestnut Borer - *Agrilus bilineatus* (Weber)

Three consecutive cool wet summers and a lack of major defoliation of oak has reduced oak mortality to background levels over most of Wisconsin. The borer continues to kill a few oaks along the Menominee River in Marinette County.

Redhumped Oakworm: *Symmerista canicosta* Franclemont

Pin oaks in the Legend Lake area of Menominee County were defoliated by oakworm for the second year.

Oak Webworm - *Archips fervidanus* (Clemens)

Small populations on understory oak were found in Eau Claire County.

Oak Leaf Skeletonizer - *Bucculatrix ainsliella* Murtfeldt

This pest caused noticable damage in Shawano and Manitowoc counties and reached outbreak levels in the city of Oneida, Brown County.

PINE

Common Pine Shoot Beetle - *Tomicus piniperda* (L.)

No infestations were found in Wisconsin during a substantial trapping and visual survey effort by pest specialists of the Wisconsin Department of Agriculture, Trade and Consumer Protection. The nearest infestation is in Illinois about 5 miles from the Wisconsin border.

Diplodia Canker and Shoot Blight - *Sphaeropsis sapinea* (Fr.) Dyke and Sutton

Infected shoots were observed in red pine plantations in Adams, Wood and Vilas counties. In western Wisconsin, infected red pine shoots were observed scattered throughout red pine plantations. Red pine shoot moth injury was often found on trees infected with Diplodia.

Root Rot of Red Pine - *Heterobasidion annosum* (Fr.; Fr.) Bref. [syn. *Fomes annosus* (Fr.; Fr.) (Cooke)]

Annosum root rot was first identified in Wisconsin in 1993 by Dr. Glen Stanosz, University of Wisconsin forest pathologist. This disease has been confirmed in 2 red pine plantations. One is in Iowa County, T8N, R4E, Section 23, NW¼, in the Arena school forest. The plantation is 40 years old and was last thinned in 1992. The stand consists of an overstory of red pine and an understory of naturally seeding white pine. Oak, red pine and raspberry are also present in the opening created by the root rot pocket.

The second site is in Adams County, T18N, R7E, Section 29, SE¼, on private property. This is a 37-year-old red pine plantation that was last thinned in 1986. There is virtually no understory vegetation; only a small number of red and white pine seedlings are present in the opening created by the root rot.

In 1994, efforts were concentrated on mapping the root rot pocket in Iowa County and experimenting with spore trapping techniques. The goal of spore trapping was to develop a simple means of detecting the presence of infectious spores in stands where a thinning is planned. If *H. annosum* is trapped, steps can be taken to minimize infection of the cut stumps. The most successful method for spore trapping required setting out freshly cut disks from red pine in Petrie dishes in and around the root rot pocket. The disks were left out for 1 to 7 days, brought back to the laboratory, and left in the Petrie dishes while the fungus grew on the disks. Efforts in the future will be made on following disease development to determine the rate of spread and refining the spore trapping technique.

Red Pine Shoot Blight - *Sirococcus conigenus* (DC.) P. Cannon and Minter

No new counties were observed with red pine shoot blight (Figure 12). In northwest Wisconsin, infections in Barnes Township, (T46N, R9W, Section 27, SW¼, SW¼), Bayfield County and Solon Springs Township, (T45N, R11W, Section 25, SE¼), Douglas County, appeared not to be spreading. New infections were observed in an area previously reported on the Chequamegon National Forest, Washburn Distrcit. The number of infected shoots increased in Vilas County near Boulder Junction. The increase in disease incidence is likely a result of the wet summer in 1993 which provided good conditions for development of the disease.

The USDA Forest Service, State & Private Forestry, initiated a survey project on the Northern Highland American Legion State Forest in Vilas County (just east of County Highway M). The objective is to determine the long-term impact of red pine shoot blight on growth and development of infected trees. Some of the red pine plantations affected by red pine shoot blight are located in low areas where late spring frost tends to occur. *Sphaeropsis sapinea* or Diplodia shoot blight has also been observed in these plantations. These multiple damages make assessment of the impact of any one problem very difficult.

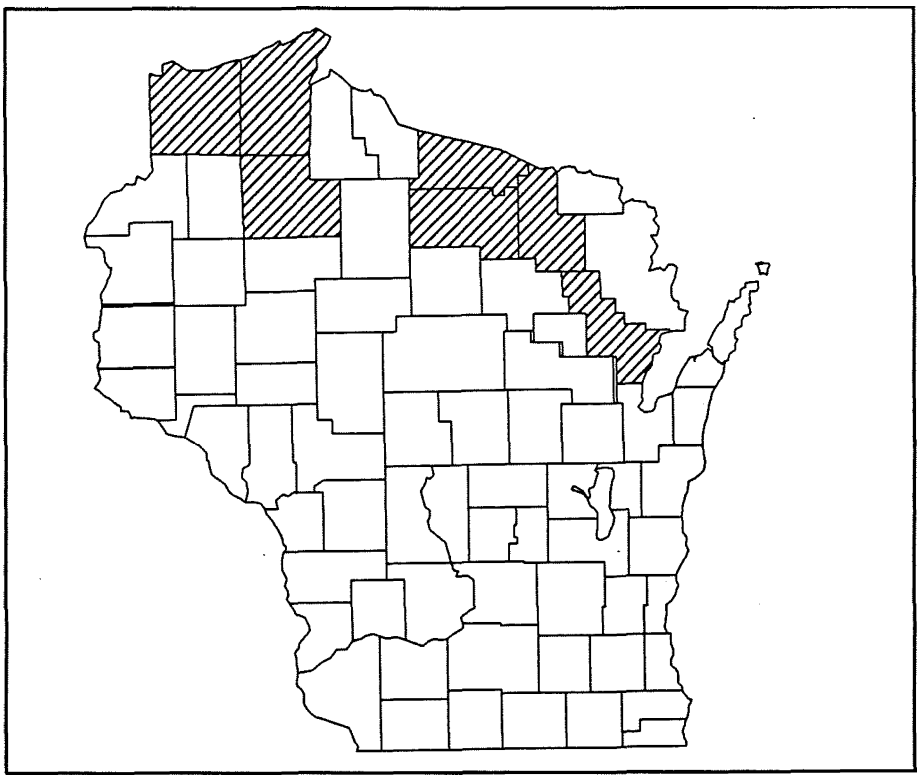


Figure 12. Known county location of Red Pine Shoot Blight, 1994.

White Pine Blister Rust - *Cronartium ribicola* J.C. Fischer

No major increase in this disease was observed. Scattered individual trees were observed in Vilas, Oneida, Lincoln, and Langlade counties. White pine blister rust caused mortality of four-year-old white pine in mixed plantings at 2 sites in Manitowoc and Door counties. Light to moderate damage on 3 to 4-foot tall white pine in Vernon County was observed. Not all the infected trees showed the typical symptom of branch flagging. The trunks of the trees had to be checked for the rust canker.

Pine Needle Rust - *Coleosporium asterum* (Dietel) Sydow

Light to moderate infection of red pine was observed in Clark, EauClaire and Vernon counties.

Pine Tussock Moth - *Dasychira pinicola* (Dyar)

Moderate defoliation occurred on over 35,000 acres of jack pine in Douglas County and on 500 acres in Bayfield County (Figures 13 and 14). Despite high egg mass counts, a substantial population decline is expected in 1995 due to a fungal infection of overwintering larvae.

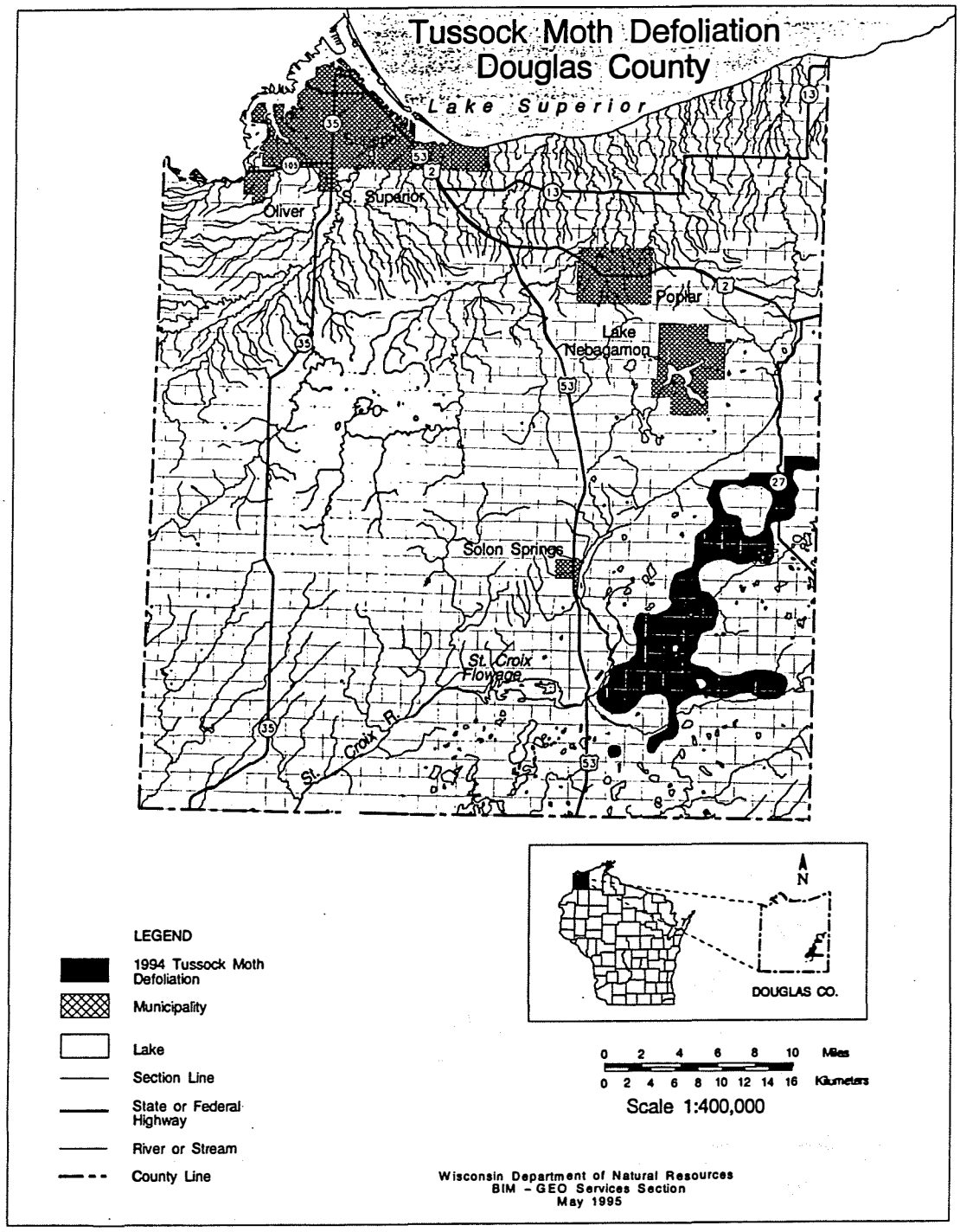


Figure 13. Area of defoliation by Pine Tussock Moth, Douglas County, 1994.

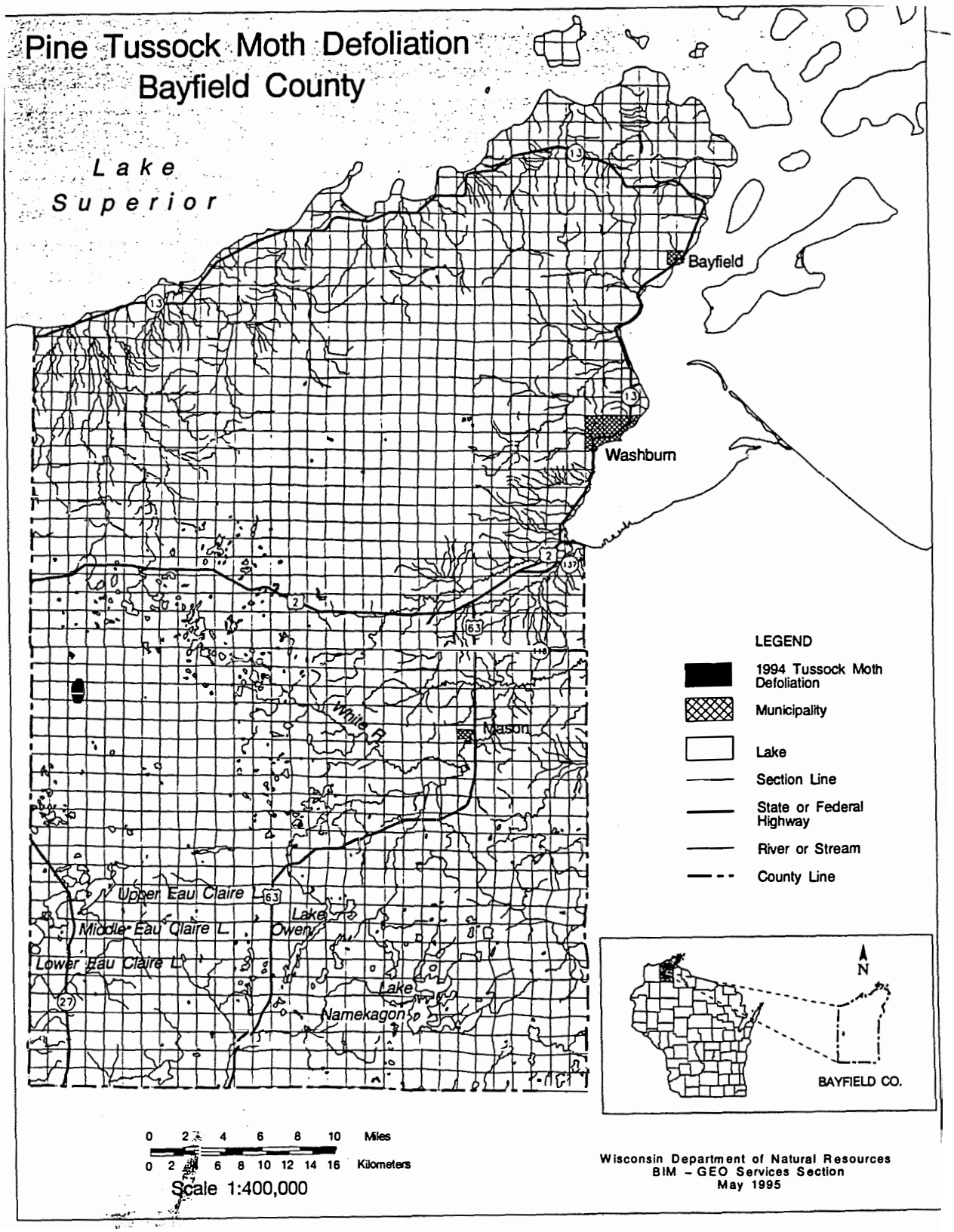


Figure 14. Area of defoliation by Pine Tussock Moth, Bayfield County, 1994.

Jack Pine Budworm - *Choristoneura pinus* (Rohwer)

Defoliation declined statewide from 400,000 acres in 1993 to 60,620 acres this year (Figures 15 to 19). Early larval numbers were very high but many of them did not develop due to lack of staminate cones on trees defoliated in 1993. There was also 21,000 acres of heavy defoliation on the Washburn Ranger District of the Chequamegon National Forest in Bayfield County.

In the northwest counties, about 47,000 acres of moderate defoliation occurred. Continued population decline is expected in 1995. Also populations are on the downward trend in Clark, Eau Claire, Jackson, and Monroe counties. The budworm larvae were feeding on foliage of jack and white pine. Larvae that were observed feeding on white pine were much larger than those feeding on jack pine. A light population was also found in Otter Creek Township of Dunn County. The overwintering population in Dunn County is low. The population decline in west-central counties is expected to continue in 1995 despite some locally high egg mass numbers.

In northeastern Wisconsin, budworm partially defoliated jack pines at sites scattered though western Marinette County. Variable results of the predictive survey in this area suggest defoliation from this pest is likely to be localized again in 1995. Budworm caused some damage to white pine plantings in Oconto County.

An isolated pocket erupted on the Northern Highland-American Legion State Forest near Boulder Junction in Vilas County where 750 acres of jack pine was heavily defoliated, and another 500 acres were lightly defoliated. Salvage harvests are being conducted.

In central Wisconsin, the early larval survey indicated a potential for high damaging populations in Adams, Juneau and Wood counties. The late larval survey found low numbers of maturing larvae and small, poorly developed third and fourth instar larvae not feeding, with many dead individuals present on branch samples. Light and heavy defoliation occurred on scattered small acreages east and southwest of Adams/Friendship (Adams County). The budworm populations collapsed in Adams, Juneau, Portage and Wood counties. Salvage harvests were conducted on 1,100 acres of jack pine in Juneau County. In Wood County, the Lake Arrowhead Property Association contracted with private contractor to spray 460 acres of the golf course and adjacent residential property with Btk. One quart per acre (16 BIU/acre) was applied by helicopter at a cost of $7.00 per acre. Good control was achieved.

Also, the DNR jack pine seed orchard in Wood County (T21N; R6E; Section 30) was treated with Asana XL to prevent damage to the seed crop. Excellent control was achieved.

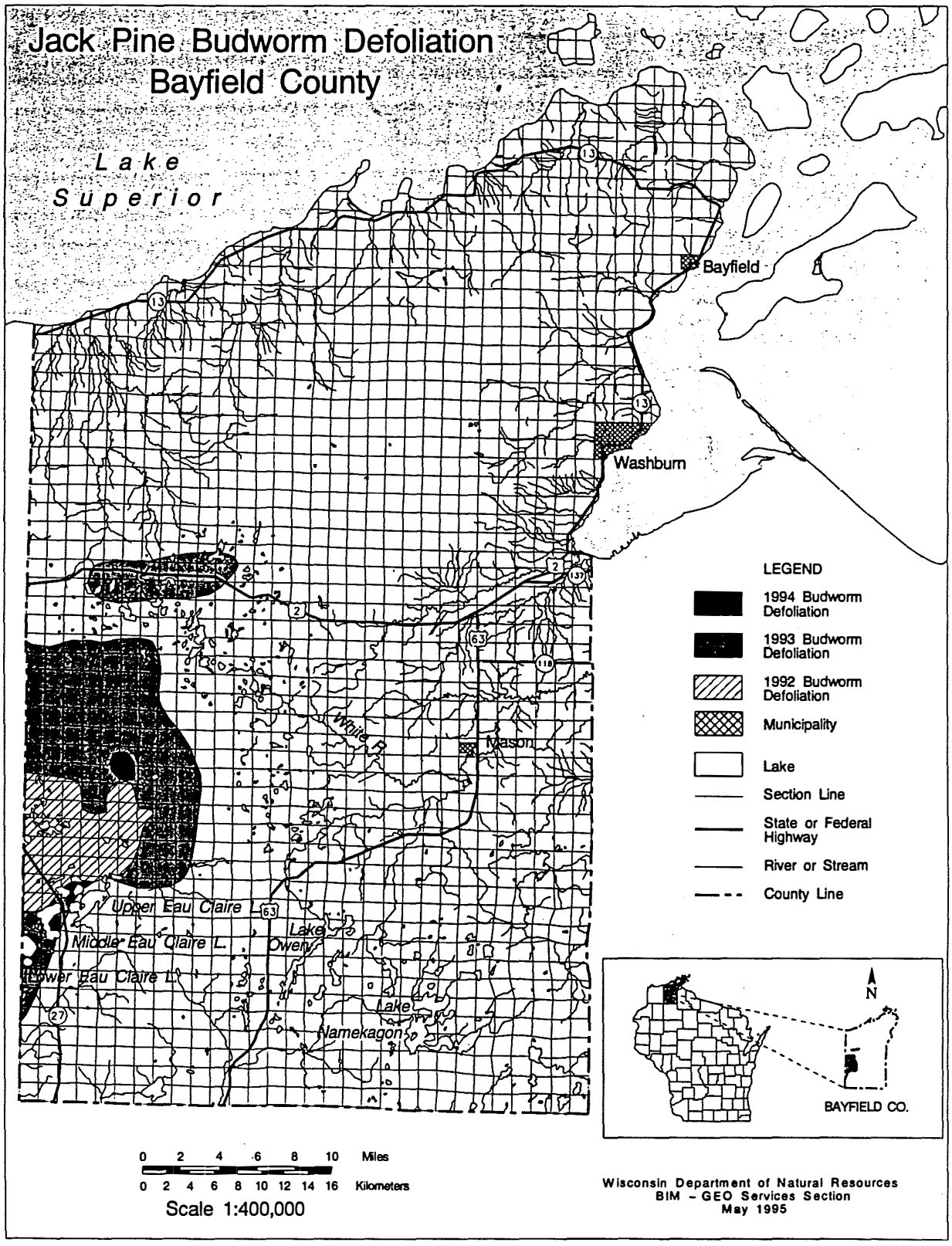


Figure 15. Area of defoliation by Jack Pine Budworm, Bayfield County, 1992, '93 and '94.

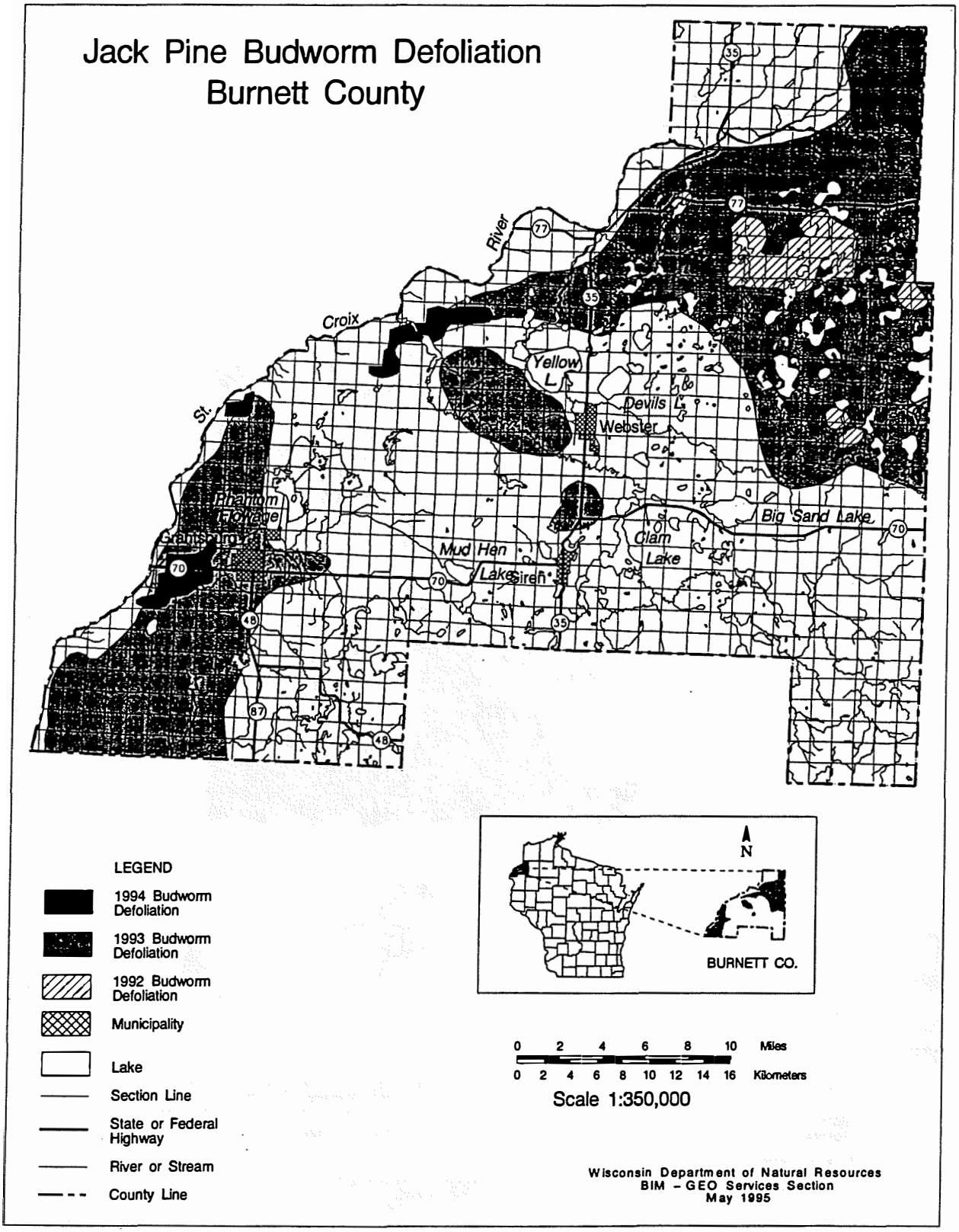


Figure 16. Area of defoliation by Jack Pine Budworm, Burnett County, 1992, '93 and '94.

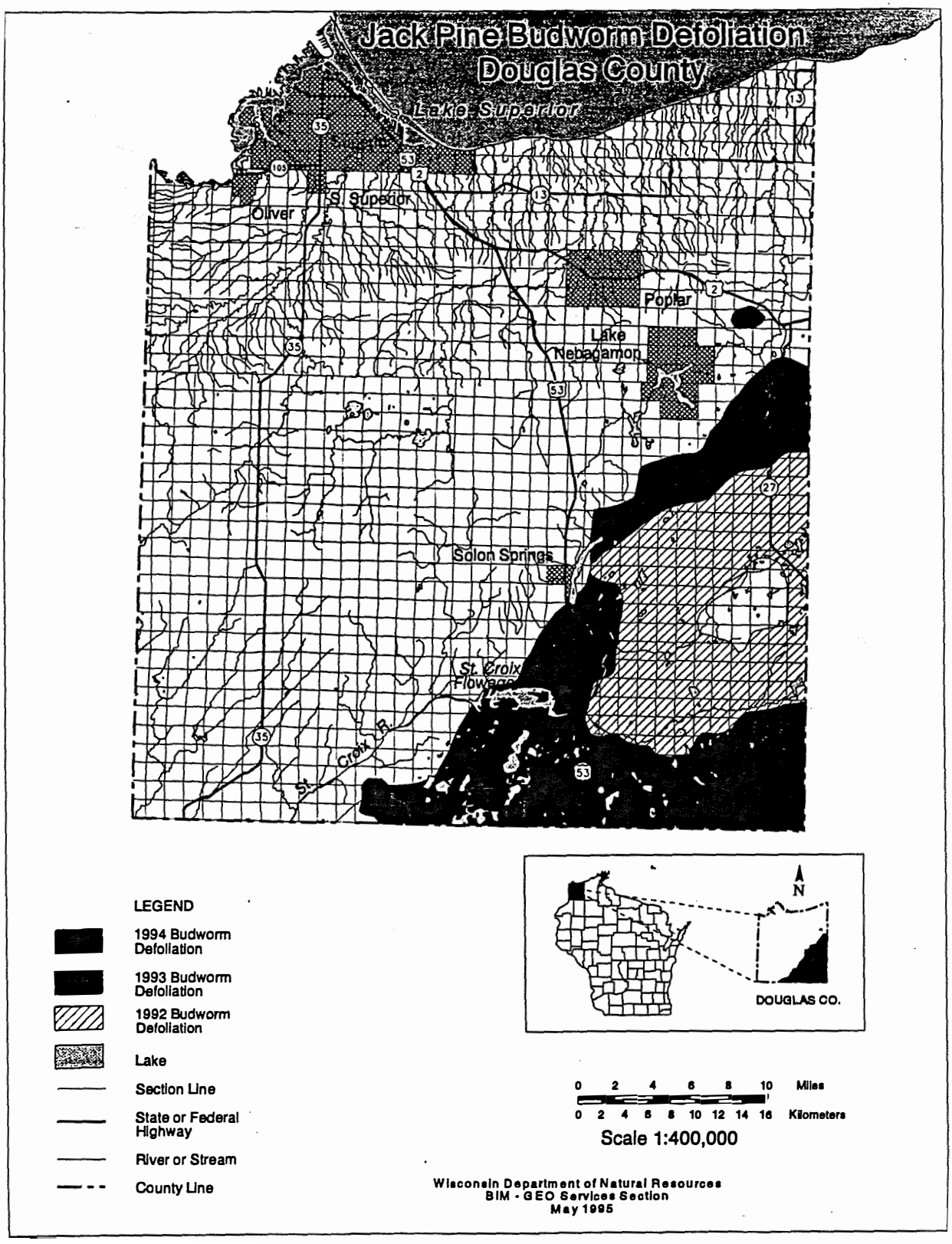


Figure 17. Area of defoliation by Jack Pine Budworm, Douglas County, 1992, '93 and '94.

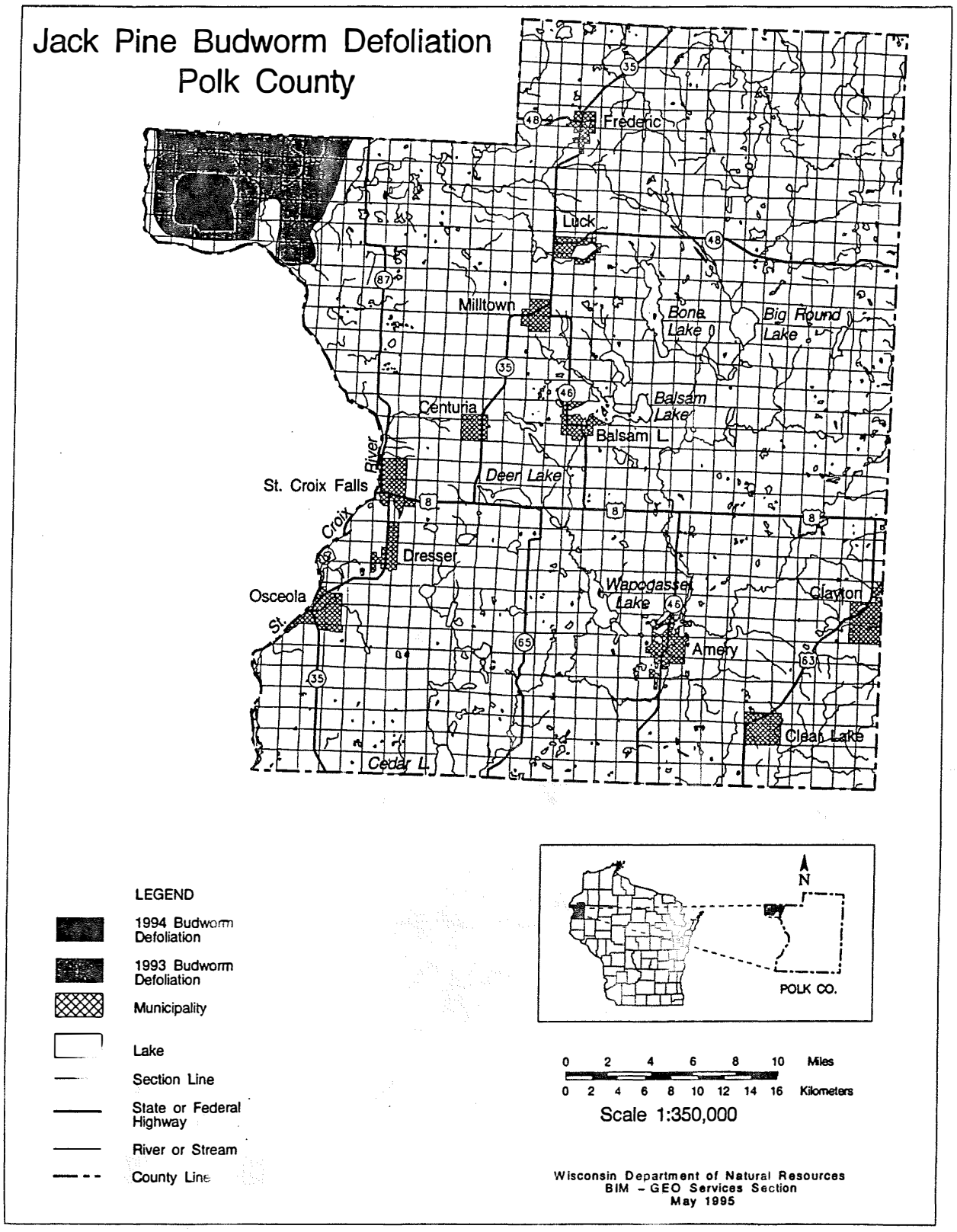


Figure 18. Area of defoliation by Jack Pine Budworm, Polk County, 1993 and 1994.

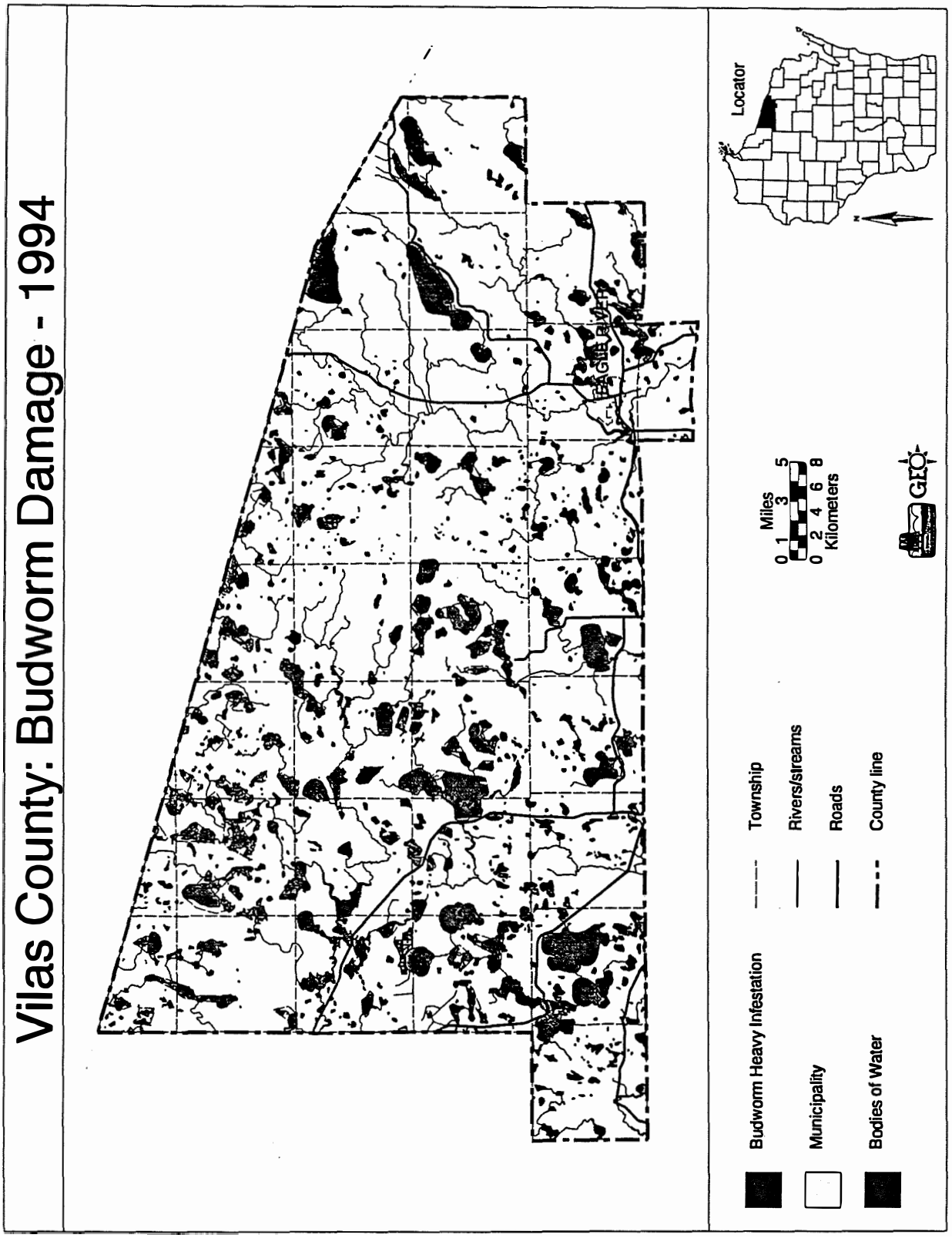


Figure 19. Area of defoliation by Jack Pine Budworm, Vilas County, 1994.

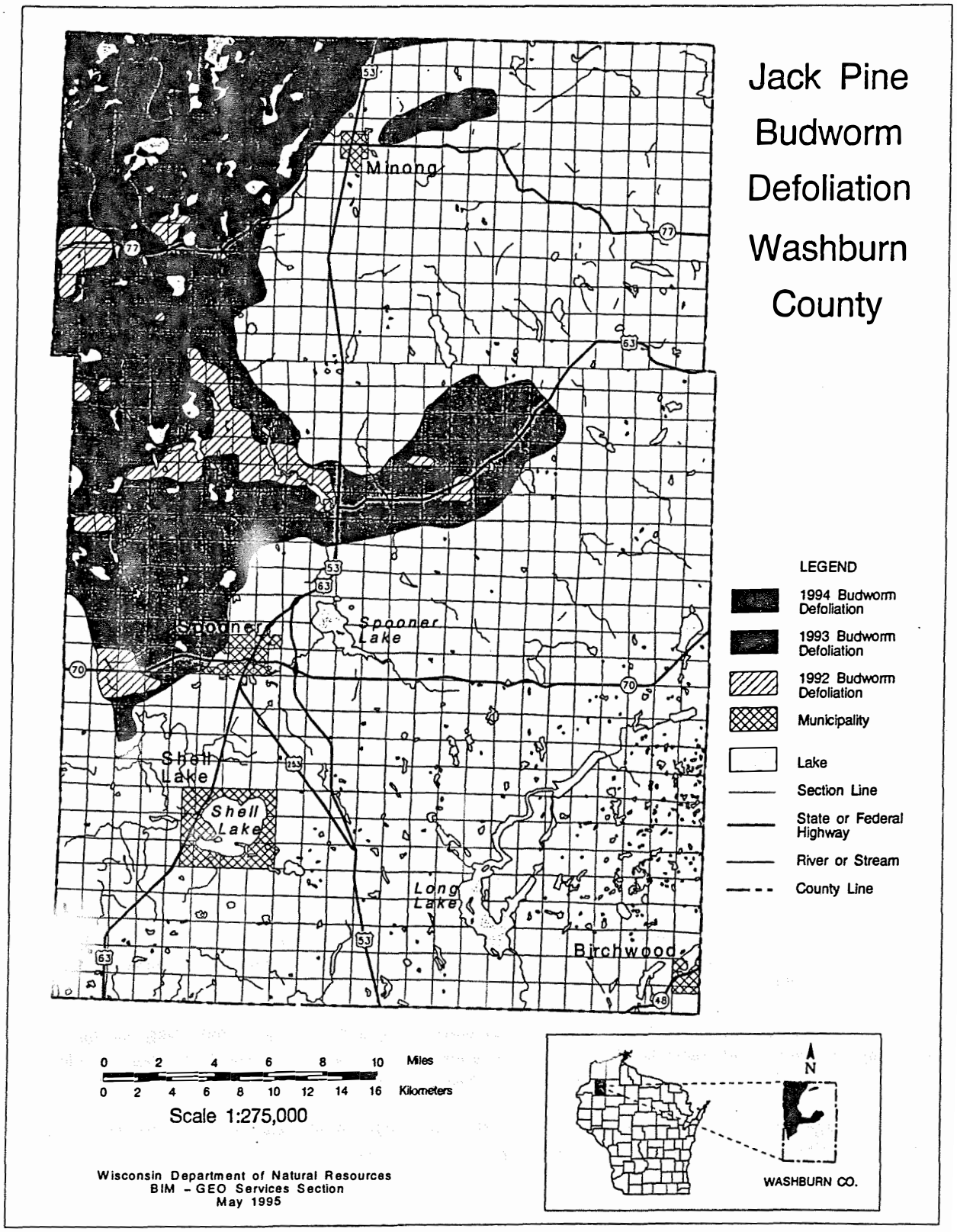


Figure 20. Area of defoliation by Jack Pine Budworm, Washburn County, 1992, '93 and '94.

Phenological Notes:

6/03/94	Few staminate flowers present on jack pine in central Wisconsin. Second and third instar larvae webbing new growth but no feeding observed on the needles.
6/14/94	Third to fifth instar larvae and pupae observed in Adams, Juneau and Wood counties.
6/23/94	Heavy flight of adults observed in a Scotch pine Christmas tree plantation, Adams County. In the jack pine stands in Adams, Juneau and Wood counties most in pupal stage.
6/21/94	High populations of 3rd and 4th instar larvae observed in all plots surveyed, Vilas County.
7/06/94	High populations of pupae observed in all plot surveyed; only 9 percent remained larval stage, Vilas County.
7/13/94	High populations of gravid females present but no eggs observed on needles collected in survey plots, Vilas County.
7/21/94	High numbers of egg clusters in some plots in the outbreak area, Vilas County.

Red Pine Sawfly - *Neodiprion nanulus nanulus* Schedl

This spring-feeding sawfly defoliated young, open-grown red pine planted in Waupaca County.

A population continued to defoliate jack pine in Solon Springs Township of Douglas County where 160 acres suffered light to moderate defoliation.

Introduced Pine Sawfly - *Diprion similis* (Hartig)

Small numbers of larvae were observed feeding on white pine in Monroe County.

European Pine Shoot Moth - *Rhyacionia buoliana* (Dinis & Schiffermuller)

Heavy shoot damage in 35-year-old, overstocked red pine growing on beach sand caused light mortality in a plantation on the Point Beach State Forest near the Lake Michigan shoreline in Manitowoc County.

Saratoga Spittlebug - *Aphrophora saratogensis* (Fitch)

A 14-year-old red pine plantation in Vilas County was observed with several areas of flagged and dead trees and a heavy ground cover of *Rubus* spp. and sweet fern. A ground survey revealed a high nymphal population. Suppression was recommended to prevent future damage and mortality.

An 8-acre planting of young red pine on the Northern Highland-American Legion State Forest (T38N; R8E; Section 22) in Oneida County was treated with malathion 57 percent EC at a rate of 1.5 pts/acre to prevent further tree mortality. No spittlebug adults were observed by sweeping foliage after 72 hours.

Severe spittlebug damage occurred in scattered pockets of young (8-12-year old) jack pine and red pine in Washburn and Burnett counties. The total area experiencing topkill or tree mortality was fewer than 40 acres.

Pine Spittlebug - *Aprophora cribrata* (Walker)

Extremely high numbers of spittle masses were evident on jack pine in the northwestern counties although reduced slightly from last years levels.

In western Wisconsin, small numbers of pine spittlebug were feeding on jack and white pine in Clark, Eau Claire, Jackson, and Monroe counties. The spittlebugs were observed in jack pine budworm defoliated areas.

The numbers of spittle masses increased in the northeastern counties this year. A few white pine saplings suffered stunting of leaders due to heavy feeding by the spittlebug.

White Pine Aphid - *Cinara strobi* (Fitch)

Light infestations on understory white pine were observed in Monroe County. A few trees were heavily infested. All the trees were in jack pine budworm defoliated areas.

A few sapling white pines in Vernon County were heavily attacked and covered with sooty mold.

White Pine Weevil - *Pissodes strobi* (Peck)

Damage to white and jack pine was very light throughout the range of the weevil in Wisconsin. Attacks were observed only on scattered open grown white pine in Langlade, Oneida and Vilas counties and in young jack pine plantations in Vilas County. Light damage was observed on 3 to 4-foot tall white pine in Vernon County.

Pine Engraver - *Ips pini* (Say)

Pine mortality had been at very low levels for several years due to cool wet growing seasons in 1992 and 1993. Flooding-stressed pines and jack pine stressed by jack pine budworm defoliation provided favorable environment for increasing populations and tree mortality.

Natural and planted jack pines that were flooded in 1993, were attacked in the spring of 1994 in Adams and Juneau counties. Second generation adults emerged in mid summer and attacked adjoining red pine plantations. Six plantations developed large pockets of dying trees in Juneau County. Salvage operations were conducted on 4 of the sites to reduce further spread within the stands.

Many budworm defoliated jack pines that were not harvested were killed by engraver beetles in Eau Claire, Jackson, and Monroe counties. Scattered attacks by the pine engraver were also found in Scotch, jack and red pine plantations in Buffalo, Eau Claire, LaCrosse, and St. Croix counties.

SPRUCE

Yellowheaded Spruce Sawfly - *Pikonema alaskensis* (Rohwer)

A spotty infestation caused heavy needle loss on highway right-of-ways and urban settings in Vilas, Oneida, Forest, Lincoln and Langlade counties. Foliage loss range from 25 to 75 percent of the crowns. Many trees will die due to needle loss.

APPENDIX A

The Development of Biological Control, as an Alternative to Methyl Bromide, for Control of Root Rot and Damping-off of Pine. Dr. Cynthia Ocamb, USDA Forest Service, North Central Forest Experiment Station.

Development of microbial applications for biocontrol of Fusarium root rot on eastern white pine (*Pinus strobus)* seedlings is underway at NCFES. Mycorrhizal fungi and rhizosphere inhabitants that are antagonistic to pathogenic *Fusarium* species have been collected. Preliminary evaluations of three different mycorrhizal species (*Laccaria* spp., *Hebeloma* spp., and *Rhizopogon* spp.) have been concluded in growth chamber studies. Two mycorrhizal fungi, *Laccaria* spp. and *Hebeloma* spp., have shown strong colonization of white pine roots. The Hebeloma spp. shows suppression of root rot as well. Biological control candidates have been collected from the rhizosphere of eastern white pine. Six different strains of *Streptomyces* spp., 9 different strains of nonfilamentous bacteria, and 2 fungi have demonstrated excellent suppression of root rot in greenhouse evaluations. Testing of the mycorrhizal fungus, *Hebeloma* spp., in combination with the rhizosphere-derived biological control candidates began in commercial containerized production during February, 1995. Examination of these candidates for control of damping-off and root rot in bareroot nurseries will begin in May, 1995. Screening is underway for discovery of nonpathogenic *Fusarium* species that can act as biological control agents for suppression of root rot.

Our biological control has expanded to other tree species and geographic regions. Development of biological control of root rot of *Pinus patula* production in south Africa is in progress. The protection of red pine seedlings by our biological control agents will be examined starting June, 1995.

REFINEMENT OF DAZOMET APPLICATION FOR SOIL FUMIGATION, J. Juzwik, USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN; R. R. Allmaras, USDA Agricultural Research Service, St. Paul, MN; D. L. Stenlund, Department of Biological Sciences, University of Minnesota, St. Paul, MN; and S. M. Copeland, USDA Agricultural Research Service, St. Paul, MN.

Dazomet (A.1, = tetrahydro-3,5,-dimethyl-2H-1,3,5, thiadiazine-2 thione) is an alternative chemical to methyl bromide for soil fumigation to control soil-borna pests in agriculture, horticulture, and forestry. The commercial product available is a fine, white granular formulation that is normally applied through drop-type spreaders, immediately incorporated into the soil, and physically sealed by rolling and applying a water seal or polyethylene tarp. The fumigant volatilizes upon contact with soil water.

Dazomet efficacy depends on the uniformity and depth of incorporation among other factors. The manufacturer of dazomet has recommended using rotary hoes and disks for the most uniform incorporation of the product. Depth of incorporation needed depends upon the pathogen or pest to be controlled; the most difficult ones (*Verticillium* and *Fusarium*) require treatment to a depth of 30 cm and an application rate of 425 kg/ha (380 lbs/ac). We field evaluated selected tillage equipment currently available to forest nurseries for incorporation of granular pesticides. Uniformity or degree of mixing and depth of incorporation were measured using ceramic spheres as tracers. Fungicidal effectiveness of dazomet to 30 cm depth is being determined in operational trials following chemical incorporation with the most promising implements. All studies have been conducted in bareroot forest nurseries with either loamy sand or sandy loam soils.

Fluorescent green or red ceramic spheres (1-3 mm dia) were evenly applied to the soil surface of two randomly determined areas (approx. 2x3m) in designated lanes of selected fields for evaluating each implement. Three rotary tillers (different manufacturers) and a digging machine were used at recommended operational tractor ground speeds and PTO rpm to incorporate the spheres. Sampling transects utilizing a wooden template with evenly spaced sampling holes were used to measure mixing/incorporation across the width of the implement lane (transverse transect at 37 degrees) or dragging of surface material (longitudinal transect parallel with direction of travel) within the soil profile. Soil cores (1.8 cm dia x 30 cm long) were taken through the holes with a tube sampler. Single soil cores ($\geq$39 per transect line) were cut into 2 cm depth increments and placed in separate envelopes; 4 cm depth

increments of three single soil cores per sampling location were composited for each longitudinal transect ($\geq$29 per line). Number of spheres in each depth increment were then determined for both sample types. Patterns of sphere distribution (horizontally and vertically) were identified for each implement. Longitudinal dragging of spheres in direction of implement travel was also found to different degrees. Spatial analysis is being used to describe uniformity of sphere incorporation. Ceramic spheres and the evaluation protocols were field worthy for evaluating equipment and associated incorporation of small, granular surface material. Functional correlation between incorporated spheres and dazomet granules will be further investigated.

The ceramic spheres also allowed for comparison of equipment performance. All three rotary tillers in this study gave a similar clustering of spheres at depths characteristic of each implement. Maximum incorporation depth ranged from 12 to 20 cm for the tillers. Extensive longitudinal drag of spheres in the top 8 cm was found for one tiller. Of the four implements tested, the digging machine produced the most consistent and deepest incorporation and the most uniform distribution of spheres throughout the depths examined. These preliminary results suggest that rotary tillers with bent lines are not the best implement type for uniformly-incorporating granular surface material.

One of two planned dazomet evaluation trials was conducted in early August 1994. Prefumigation soil samples were taken to assay *Fusarium* spp. and *Cylindrocladium* spp. at different depths. Dazomet was then applied to the *Cylindrocladium* spp. at different depths. Dazomet was then applied to the field with a drop-type spreader; half the field received 285 kg/ha (255 lbs/ac) and the other half received 570 kg/ha (510 lbs/ac) of product. Four contiguous traffic lanes were established across each half for the entire length of the field 15.5x155.4 m (51x510 ft.). Each implement was then used to incorporate the dazomet in the implement's designated lanes. Two of the four implements were equipped with a roller that immediately compacted the soil surface. After all incorporation was complete, a separate roller was used to compact the surface soil across all treatments before irrigating. Soil cores were taken after rolling but before watering to determine chemical activity by depth in each treatment. A lettuce seedling bioassay was used to indirectly assess this activity. Measurements of soil resistance to penetration were taken with a cone penetrometer before and after tillage to accurately determine tillage depth. Chemical bioassay correlated well with distributional patterns determined for each implement in the screening trials with spheres. Fungal populations determined for post-fumigation soil samples (4 wks after treatment) will be compared with the chemical assay. We anticipate that direct readings methylisothiocyanate levels (primary breakdown product of dazomet) in the soil at different depths will be made in the 1995 field trial.

In summary, ceramic spheres are useful as tracers for evaluating tillage equipment and associated incorporation of surface-applied, granular material. Due to nonuniform and shallow mixing, rotary type tillers may not be the best implement type for incorporating granular fumigants. Chemical field trials are currently underway to test this observation.

APPENDIX B

Guidelines for Pruning Oak to Minimize the Overland Spread of Oak Wilt

by Jane Cummings Carlson

A effort was made to develop guidelines for the timing of pruning and cutting oak to reduce the overland spread of this disease. Though it sounds easy, different recommendations regarding the timing of pruning oak have been proposed by various researchers and tree health professionals and inconsistencies in recommendations have caused confusion for foresters, tree care specialists and the general public. In an effort to come up with a statewide standard for arborists, homeowners and foresters, the research on this topic was summarized and several proposals presented to representatives from the following groups: electric utilities, tree care and building industries, the Wisconsin Urban Forestry Council, university researchers, and the Department of Natural Resources silviculture committee and forest pest specialists. The result of this are 2 sets of guidelines: 1 for arborists and homeowners and 1 for foresters. A plan has also been developed to evaluate concerns expressed by some researchers and tree care professionals regarding timing of pruning and effectiveness of tree wound dressings in preventing oak wilt. A 5-year survey will be conducted in cooperation with Wisconsin Power & Light and Wisconsin Public Service Corporation to follow various pruning practices from April 15 to September 15 and determine the effects various practices have on the overland spread of oak wilt.

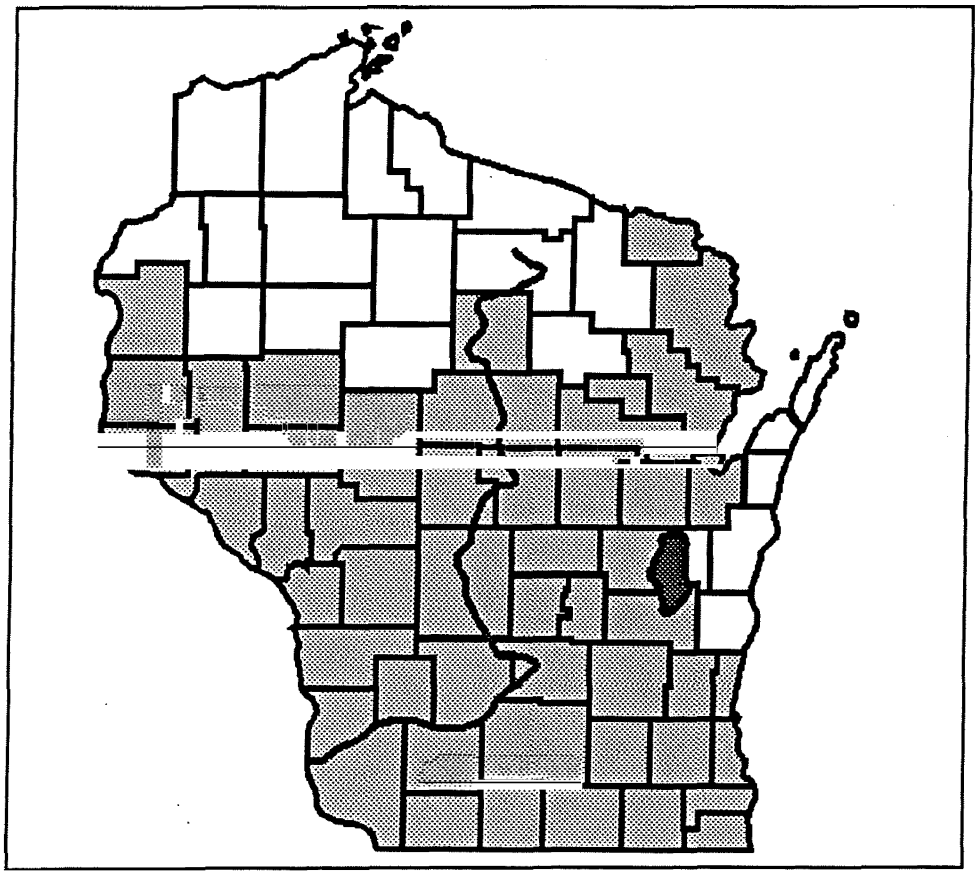


Figure 21. Counties where Oak Wilt guidelines are recommended.

Oak Pruning Guidelines for Arborists and Homeowners
For all counties where the presence of oak wilt has been confirmed (Figure 20) plus Florence and Lincoln (where oak wilt borders the county)
April 15 - July 1: No pruning or cutting of oak except in emergencies. Pruning paint must be applied as soon as possible to all final cuts (branches and stumps made in emergencies).
July 2 - April 14: No restrictions
For counties where oak wilt has not been confirmed. No restrictions are recommended.

Oak Cutting Guidelines
For all counties where the presence of oak wilt has been confirmed (Figure 20) plus Florence and Lincoln counties (where oak wilt borders the county).
April 15 - July 1: No pruning or cutting of oak except in low risk situations*.
July 2 - April 14: No restrictions recommended.
For counties where oak wilt has not been confirmed. No restrictions recommended.

* The following low risk scenarios describe cutting that may be conducted at any time due to the low risk of increasing the overland transmission of oak wilt.

1. Any cutting where oaks (5-inch+ size class) represent <10 percent of the forest tree composition in a fully or overstocked stand.

2. Clearcutting patches of oaks where the adjacent forest cover types do not have a significant oak composition (oaks in 5"+ size class represent <10% of the forest tree composition in a fully or overstocked stand).

APPENDIX C

FOREST HEALTH MONITORING

Introduction

In recent years, there has been considerable interest in how forest pests, air pollution, other stressors, and management methods are affecting our Nation's forests. In response to these concerns, the National Forest Health Monitoring Program (FHM) was established which measures, interprets, and reports the effects of these factors. FHM was implemented in New England in 1990 and in the Lake States in 1994 (Figure 22). FHM is a cooperative program between the U.S. Environmental Protection Agency, USDA Forest Service, and local state forestry and/or agriculture agencies

Program Goals and Objectives

* To characterize forest conditions and the major potential forest stressors.
* To detect and quantify changes in forest conditions and forest stressors.
* To analyze the relationships between changes in forest conditions and potential forest stressors.
* To provide information to guide management and protection activities.
* To report and interpret these changes at a multistate level.

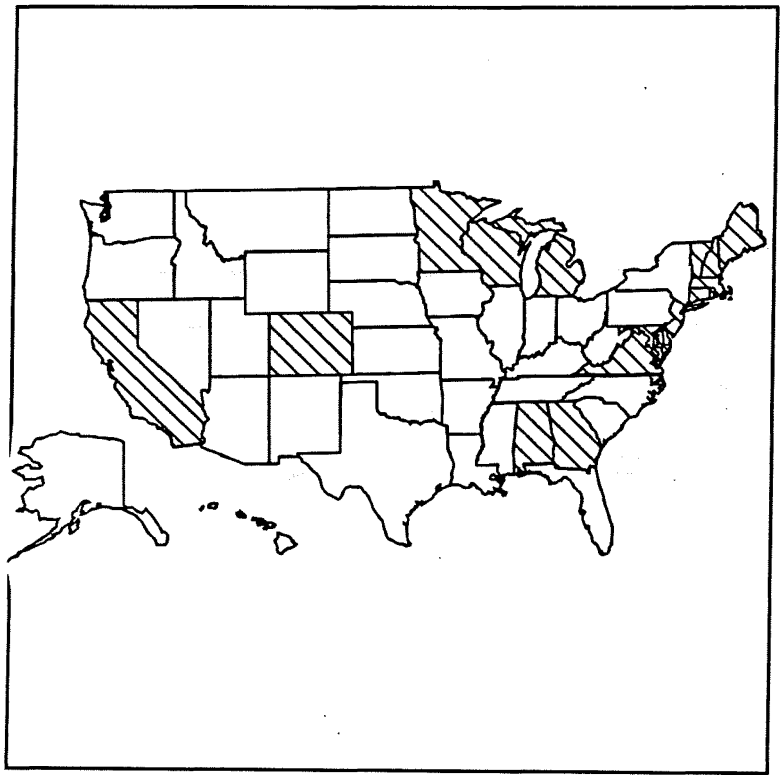


Figure 22. States participating in FHM, 1994.

Detection Monitoring

The basis for FHM is a set of plots distributed on a systematic grid across the United States. There are an estimated 3,800 forested plots in the United States. Part of the FHM network includes 5 *bioindicator* plots in Wisconsin. Injury to sensitive plants from the air pollutant ozone, is monitored on these plots.

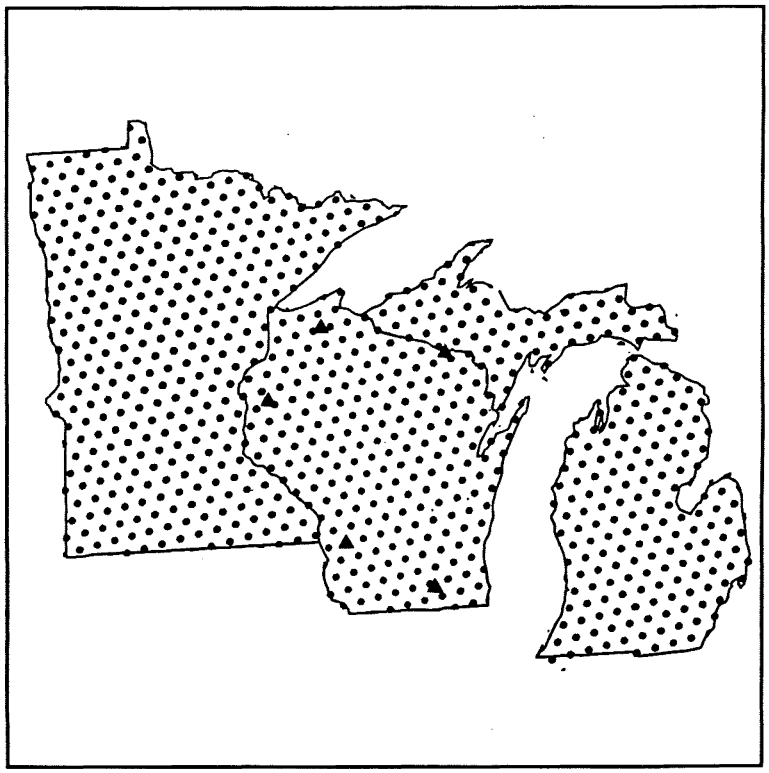
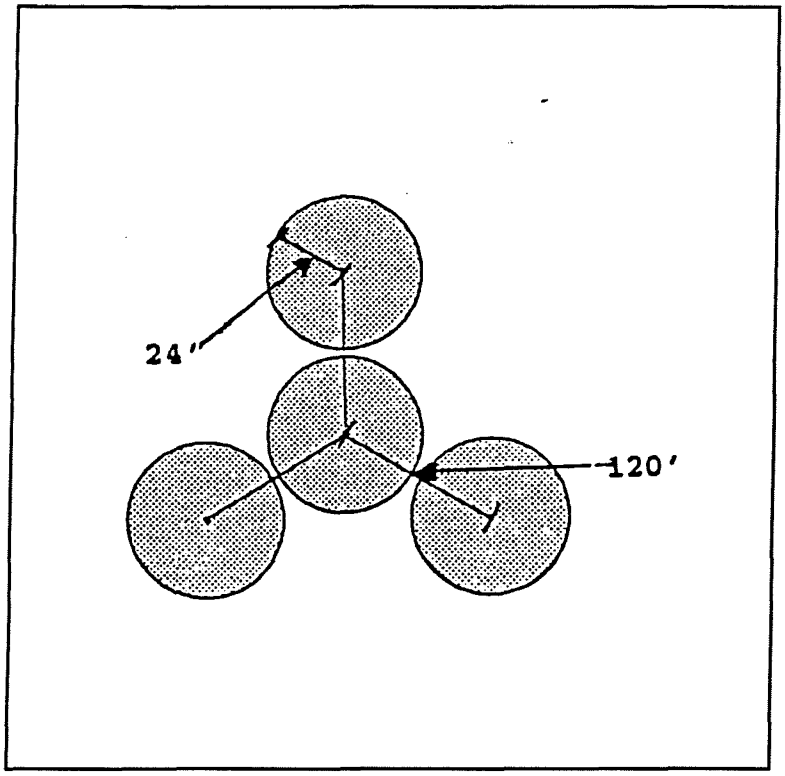


Figure 22. FHM plot network:
0 = FHM plot location;
▲ = location of broindicator plots for detection of ozone injury

	NUMBER OF PLOTS		
STATE	FORESTED	NONFORESTED	TOTAL
Wisconsin	92	131	223
Michigan	133	114	247
Minnesota	121	216	337



Each plot consists of 4 subplots (Figure 23). Each subplot is a fixed area plot, with a radius of 24 feet. There are 120 feet between each subplot center. Measurements of the detection plots include the following indicators:

1) Mensuration,
2) Crowns (density, transparency, dieback),
3) Tree damage assessment,
4) Bioindicators (plants showing symptoms of air pollution injury),
5) Vegetation diversity,
6) Lichens, and
7) Photosynthetically active radiation.

FHM requires annual measurements of these indicators in an effort to detect *changes* in the forest over time.

Figure 23. Forest Health Monitoring Plot.

How is FHM being implemented in Wisconsin?

In Wisconsin, the FHM program was implemented through cooperation between the **Lumberjack RC&D** (Resource Conservation and Development), **Don Peterson**, coordinator; and **Bureaus of Forestry and Air Management, Jane Cummings Carlson and Ed Jepson**, coordinators respectively. One field coordinator and 6 field personnel were hired to locate, establish, and collect data on the detection plots. One, 2-person crew was located in Hayward, 1 in Tomahawk, and 1 in Wautoma. The crews were in the field from early June through mid-August and visited 92 forested plots and 131 nonforested plots. Measurements on the 7 indicators were collected on the forested plots only.

What is the future of FHM in Wisconsin?

All or ¼ (depending on the national direction of the program) of the 92 forested plots will be visited annually. Data from Wisconsin will be joined with data from other participating states to strengthen the base of information. The U.S. Forest Service will be summarizing the data on a regional basis in forest health reports.

How does FHM tie in with Forest Inventory and Analysis (FIA)?

The 2 plot networks are completely independent. FIA and FHM plots are configured differently. The data collected also differs. Linking the 2 programs would strengthen the mensuration data for FHM and broaden the forest health data for FIA. The process to tie the 2 networks together has just begun. The Lake States have located their FHM plots in the same location as the FIA plots.

How does FHM tie in with Wisconsin DNR?

The FHM program provides data significant at a multistate level. To interpret FHM data on a level significant to Wisconsin, the information must be combined with detection and survey data collected by DNR personnel from many different programs. Some of this information includes data on forest pests; air pollution; fire; weather and climate; forest, wildlife and endangered resources inventories; and land use patterns.

Forest Health Monitoring - Ozone plots

Part of the FHM program includes evaluation of bioindicator species for the incidence and severity of injury from the air pollutant ozone. Bioindicator species at 5 sites (Figure 24) were evaluated during the week of August 15 to 19, 1994, for symtoms of ozone injury. The survey indicated ozone injury was most apparent in late August and early September. The greatest amount of injury was observed in Polk County, which is downwind of the Minneapolis-St. Paul metropolitan area. Leaf injury of bioindicator species was most noticeable in the counties bordering Lake Michigan, yet there are no established FHM biomonitoring plots in this area. Additional plots, particularly in eastern Wisconsin, would provide a more comprehensive survey of the severity and extent of ozone injury in the state. The following results were submitted by Edward Jepson, Environmental Studies Unit (ESU) in the Bureau of Air Management.

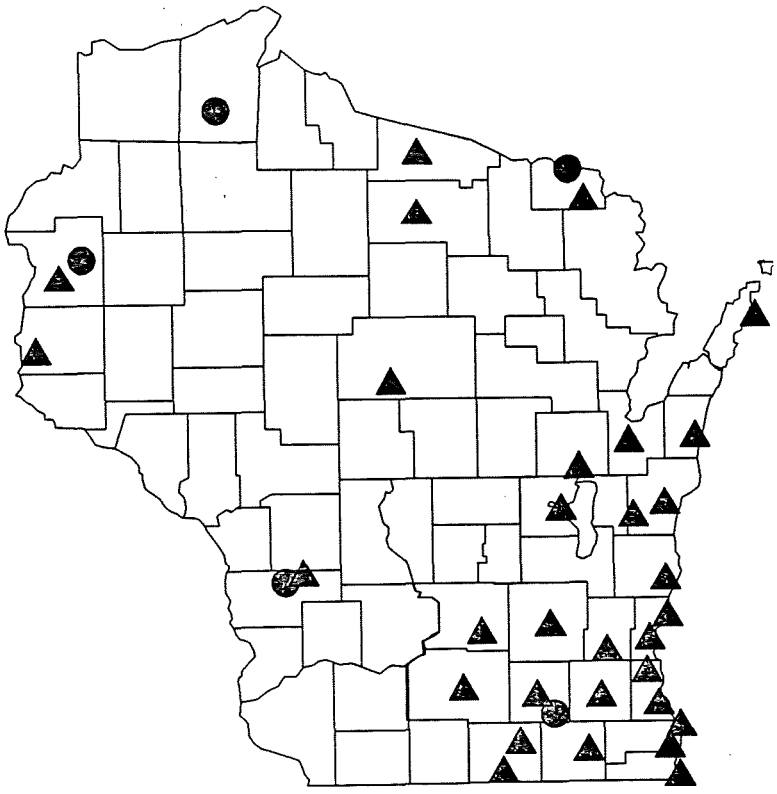


Figure 24. Location of Ozone Monitoring Equipment = ▲ and FHM Ozone Monitoring Bioindicator sites = ●

Table 9. Number of plants of various bioindicator species with symptoms of ozone injury.

	COUNTY				
SPECIES	FLORENCE	BAYFIELD	POLK	VERNON	JEFFERSON
Milkweed	0 of 30 injured	0 of 30 injured	6 of 30 injured	1 of 30 injured	2 of 30 injured
Dogbane	0 of 30 injured	0 of 30 injured	8 of 30 injured	np[1]	3 of 20 injured
Big Leaf Aster	0 of 30 injured	0 of 30 injured	0 of 27 injured	0 of 26 injured	np
Blackberry	0 of 30 injured	0 of 30 injured	0 of 30 injured	0 of 30 injured	np
Black Cherry	0 of 30 injured	0 of 30 injured	0 of 14 injured	0 of 30 injured	0 of 30 injured
Ash[2]				0 of 30 injured	

[1] NP = Not present or in numbers too low to evaluate.

[2] Consists of a mixture of white and green ash

Table 10. Amount and severity of leaf area injured by county and species.

COUNTY	SPECIES	AMOUNT[3] & SEVERITY[4] OF INJURY
Florence	All species	No apparent ozone induced foliar injury
Bayfield	All species	No apparent ozone induced foliar injury
Polk	Milkweed	Amount = 1,1,1,1,1,1 Severity = 1,1,1,1,2,1
Polk	Dogbane	Amount = 1,1,1,1,1,1,1,1 Severity = 1,1,1,1,1,1,1,1
Vernon	Milkweed	Amount = 1 Severity = 1
Jefferson	Milkweed	Amount = 1,1 Severity = 2,1
Jefferson	Dogbane	Amount = 1,1,2 Severity = 1,1,2

Amount of ozone injury: 0=no injury; 1=1-6% of the leaves are injured; 2=7-25%; 3=26-50%; 4=51-75%; 5=>75%.

Severity of ozone injury: 0=no injury; 1=1-6% of the leaf area of injured leaves only are affected; 2=7-25%; 3=26-50%; 4=51-75%; 5=>75%.